POWER PLANT ENGINEERING

Established Over 29 Years

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Make Waste Pay

AMERICA IS A LAND of wonderful resources and as such we can feel justly proud. In the past, however, America has not always been a land of resourcefulness. It is true that the early pioneers were forced to accept nature as it was found and to convert it, even by destructive methods, so that it would support advancing civilization. Not long afterward, however, a period was reached when it was no longer necessary to waste timber in order to provide land for tillage. Unfortunately the waste did not stop. Forests were destroyed according to the avarice of those who could get to them first. The consumer is not without blame for his careless use of the products of the forest.

Up to the present time we have uprooted our way to the extreme edge of our forest reserves. We are only now beginning to appreciate that the waste products of the lumber business can be burned scientifically and economically to produce power. Waste products which have a fuel value should no longer be allowed to accumulate where they actually constitute a hazard as indicated in the above picture. They should be used as shown in the article on page 837 of this issue, which points out the trend of recent developments in waste wood burning.

Lake Erie Water Purified for Monroe, Mich.

WATER PUMPED BY OLD STATION TO NEW PUMPING AND PURIFICATION PLANT WHERE FILTERED WATER IS STORED IN UNDERGROUND RESERVOIR

HISTORY RECORDS that the second oldest city in Michigan is Monroe, which was first settled by the French, July 14, 1817. The original settlement was comparatively near the shore of Lake Erie, however, that location not having proven the best, the present City of Monroe proper is now found to be a distance inland of approximately 3½ mi., its boundary still stretching to the Lake. Monroe now stands on comparatively high ground where drainage and sanitary conditions are much more favorable than they were at its original location.

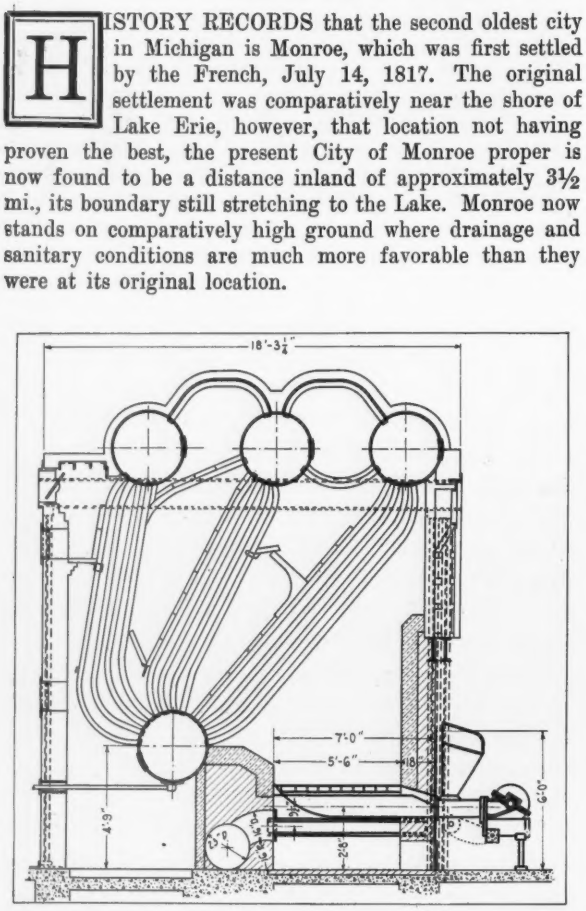


FIG. 1. FORCED BLAST DUCT RUNS THROUGH THE BRIDGE WALL

Monroe has now grown to be a city of 14,000 inhabitants and it has come to the full realization that it must have an adequate supply of water, which can be safely used by its citizens. Up until about a year ago, the city water supply had been taken care of by an old pumping plant, which was located about 4 mi. from the City of Monroe and about ¾ mi. from Lake Erie. Many parts of Lake Erie are quite shallow and the original crib which was constructed northeast of Monroe and out a distance of about 2100 ft. from the shore is submerged in only about 12 ft. of water.

Characteristic of intakes located in the waters of the Great Lakes a great amount of trouble has been experienced due to the formation of needle ice which tends to choke off intakes and thus limit the flow of water to the suction wells. When this condition takes place, it is necessary to stop drawing water through the intake and to pump water for a short time in the opposite direction. This backwashing is done with water drawn from a small storage reservoir of about half million gallons capacity, which is located near the old pumping plant.

It was hoped to eliminate this trouble by the construction of a second intake of different design which would so reduce the velocity of water entering the crib as to do away with future trouble from this source, and therefore in line with the general improvements which were being placed, a second crib was constructed in the vicinity of the first crib and tied into the original 20-in. intake pipe by means of a tee.

Flow of water from the cribs or intakes to the old pumping station is by gravity through a 20 in. pipe laid along the bottom of the lake. This old station is now referred to as the low pressure station and its duty is to pick the water up from the suction wells that are filled by gravity from the lake and deliver it to the settling basin at the new station, or high pressure station, where the filtration plant is also located. As previously stated, it is about

3½ mi. from the old to the new station. It is seen from this that the old station has become but a link in the system which now supplies water to Monroe.

Water Is First Treated With Alum

Tie in between the old and new stations is made by a 24 in. main. Alum is fed into this main at a point near the new station just before the water is discharged into the settling basin or coagulation tank. During the winter months the turpidity of the water is usually low so that only 0.7 gr. of alum is required per gal. of water. In the spring and fall the turpidity is usually the highest of the year and during these seasons 3 or 4 gr. of alum may be used per gal. of water pumped to the city.

The coagulation tank is a concrete structure and arranged in compartments. Drainage from it is under the control of the operator in the filter room. This basin or tank is octagonal in shape, two lobes forming one compartment, there being four compartments in all. Any one compartment or a combination of compartments may be used, thus making the basin extremely flexible for operating and cleaning simultaneously. The purpose of the coagulation basin is simply to provide a place in the path of the water flow where the velocity will be extremely low and thus allow time for the coagulate, resulting from the use of the alum, to settle out and later be washed to the sewer.

The water flows by gravity from the coagulation tank to the sand filter beds, of which there are four, each being rated at 1,000,000 gal. per 24 hr. Flow through the filters varies of course with the length of time that they have been in service, for, like any other filters, they must be backwashed after having been in operation for a certain length of time. The purpose of these filters is to remove the lighter particles of coagulation which cannot readily be settled out.

Construction of the sand filters is quite interesting. They are essentially large concrete boxes in the bottom of which is placed a manifold system of pipes which gathers the water after it has been filtered down through the sand. These same pipes are also used to force water up through the sand when it is being backwashed. During the backwashing period, the water overflows into troughs at each side and at the center of each filter and is drained away to the sewer.

Spread evenly over this manifold pipe system are three grades of gravel, the coarsest grade being placed nearest the pipe. This gravel bed is approximately 18 in. deep.

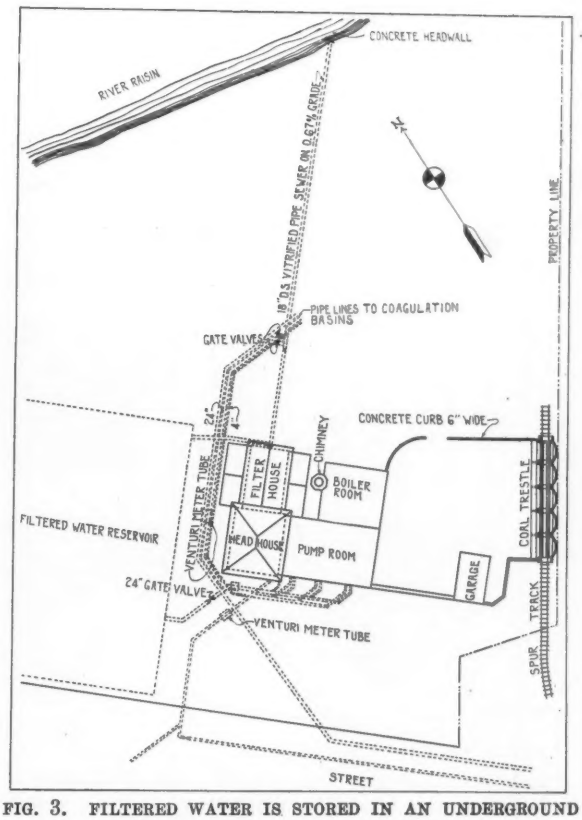


FIG. 3. FILTERED WATER IS STORED IN AN UNDERGROUND RESERVOIR NEAR THE PUMPING PLANT

Over the gravel is placed a 30-in. bed of sand, which is the essential part of the filter and is that part which removes all remaining suspended matter in the water. This sand is of a special grade used for filter purposes. It is known as No. 32 Cape May sand and is obtained in the state of Maine. Replacement or removal for cleaning of this sand may be required every 2 to 10 yr., depending upon the manner of operation as well as the character of the water which is to be filtered. The Monroe filter plant has been in operation less than a year, so no records are as yet available as to the length of time that one batch of the filter sand will be of service.

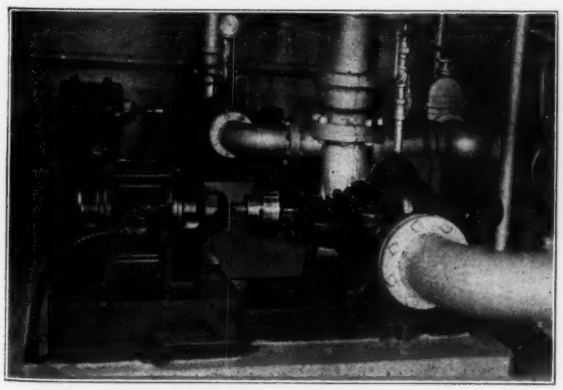


FIG. 2. MOTOR DRIVEN PUMPS ARE USED FOR HOUSE SERVICE DUTY

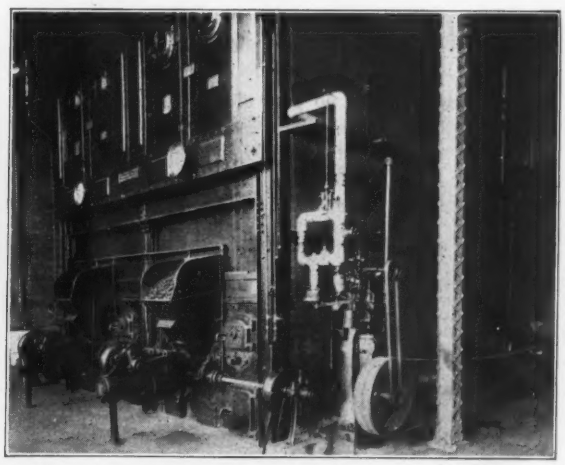


FIG. 4. ONE ENGINE DRIVES BOTH STOKERS AND THE BLAST FAN

From the sand filters the water flows by gravity to a storage reservoir of 3,000,000 gal. capacity. We ordinarily think of a reservoir of the above capacity as an uncovered storage space. This is not the case, however, in this instance, for this storage reservoir is in reality a huge tank made of reinforced concrete. The bottom of this tank rests on solid rock. Its depth is 14 ft. and the roof is also of reinforced concrete and is slightly above the street grade. The top soil has been spread back over the roof and seeded so that no part of this 3,000,000-gal. reservoir can be seen.

This reservoir is, in fact, a large clear well and serves as a balance wheel against the sudden demand for water by the city. It is the source of supply which is drawn on by the high pressure station, filtration plant and pumping units, which are located so that the water flows to them by gravity.

As previously stated, four sand filters have been installed. They are arranged two on each side of the filter room. Located in the aisle between the filters and opposite each filter is an operating table, which is provided with instruments to give complete control over the operation of the filter which it serves. On each table are levers which control the opening and closing of the hydraulically operated water supply valves. They may be operated by the city water pressure or by an auxiliary water pump, which can be used in the event of the failure of the city water pressure.

Filter Washing Period Depends Upon Resistance to Flow

Also mounted on these stands are recording flow meters, which show the rate of flow through the filter beds, loss of head gages and wash water gages. These instruments are extremely valuable because they show the resistance to flow and thus indicate the condition of the filter. With this information available, it is an easy matter to determine the proper time for back washing the filters. During the winter months the average run of a filter between washings is about 50 hr.

Each stand is also equipped with a water sampling device and an automatic control, which can be set for any given flow, or which will work entirely automatically and regulate the flow so that it will be constant, regardless of the conditions of the filter bed. This control equipment was furnished by the Keystone Machine and Engineering Co. In order to keep operating conditions before the operators at all times a Foxboro altitude meter records the depth of the water in the reservoir or clear well.

Although a filter has been thoroughly washed, still it is not considered good practice to send to the city the first water to be filtered. Therefore, after the backwashing has

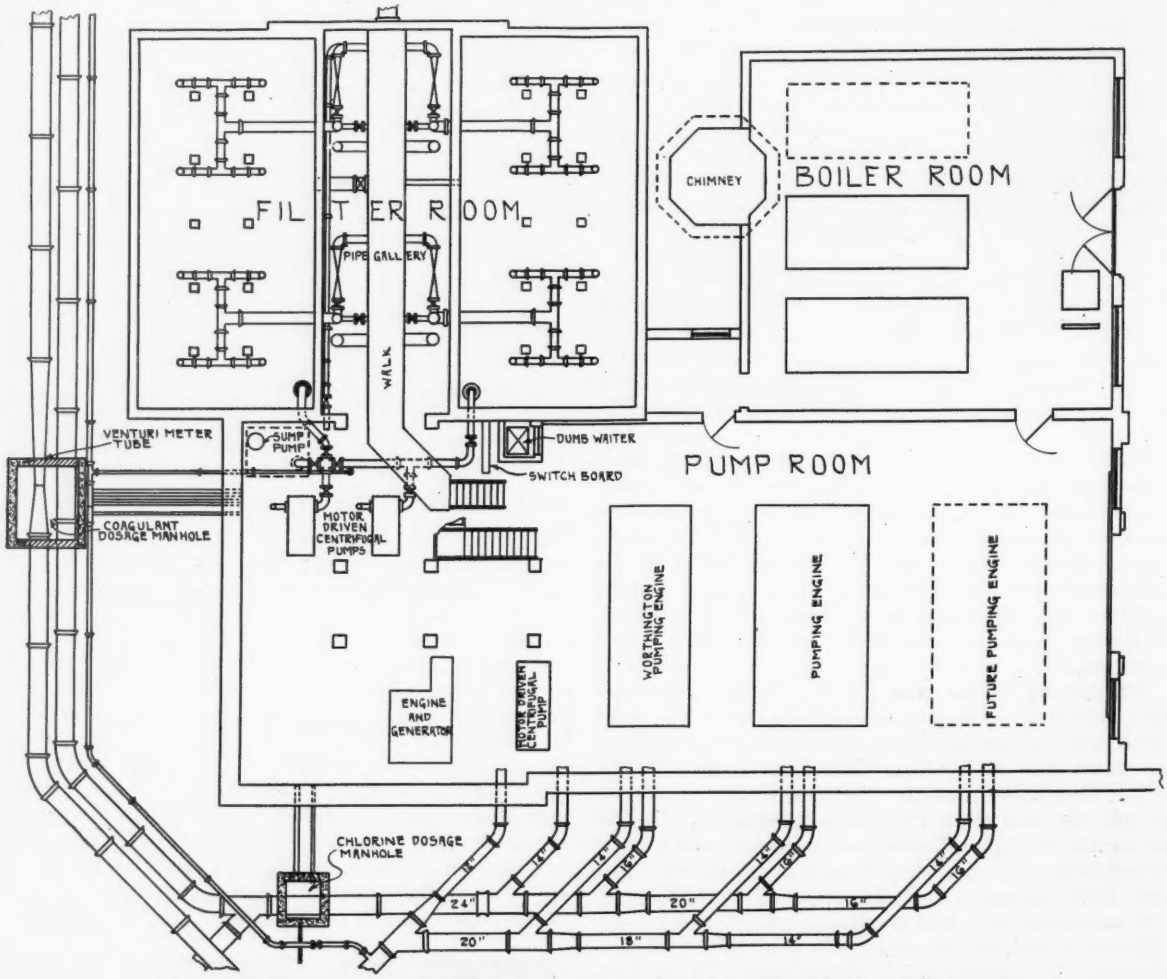
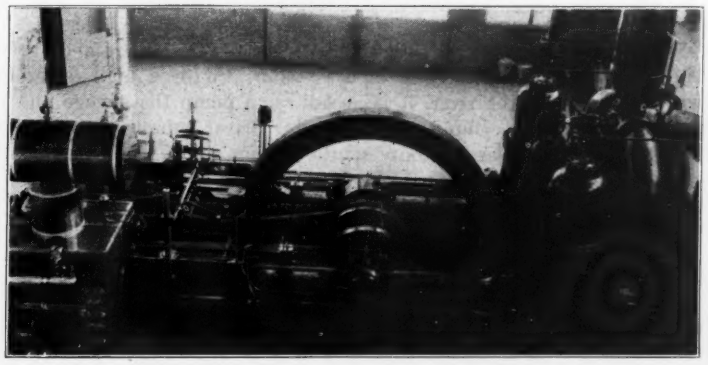


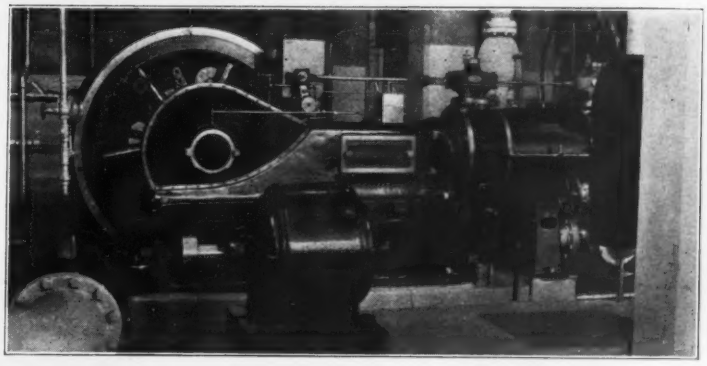
FIG. 5. PUMP ROOM IS AT RIGHT ANGLES TO THE FIRING AISLE IN THE BOILER ROOM

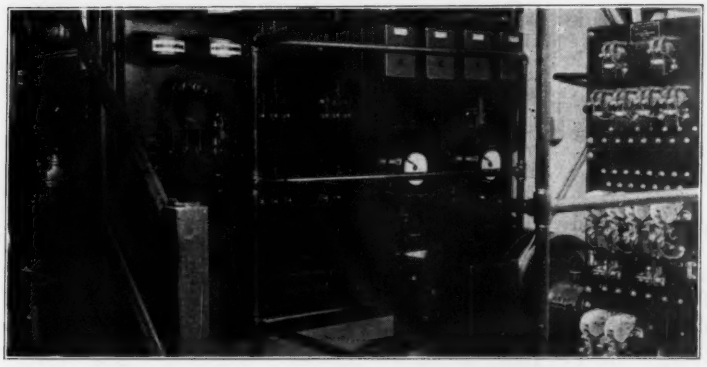
Views of Equipment in Monroe's New Pumping Plant



ONE CRANK AND FLYWHEEL PUMPING ENGINE HAS ALREADY BEEN INSTALLED AND IS NOW CARRYING THE WEEK-DAY LOAD. FLOOR SPACE REMAINS FOR TWO MORE STEAM DRIVEN UNITS LIKE THE ONE SHOWN OPPOSITE. THE SUNDAY LOAD IS CARRIED BY A MOTOR OPERATED CENTRIFUGAL PUMP; CURRENT FOR WHICH MAY BE TAKEN EITHER FROM AN ENGINE DRIVEN GENERATOR INSTALLED IN THE PUMPING PLANT OR FROM A SERVICE LINE FROM A PUBLIC UTILITY.

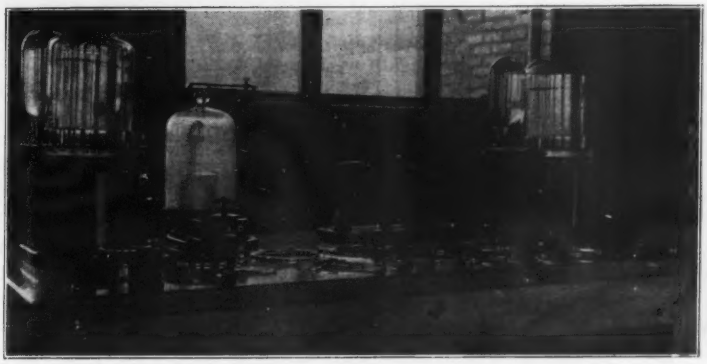
IN THE BACKGROUND CAN BE SEEN THE UNIFLOW STEAM ENGINE WHICH IS DIRECT CONNECTED TO AN ELECTRIC GENERATOR, SUPPLYING CURRENT FOR THE OPERATION OF VARIOUS MOTORS ABOUT THE STATION. THIS ENGINE OPERATES ONLY PART OF THE TIME, THAT IS, WHEN THE STATION DEMAND FOR ELECTRICITY IS HEAVY. A SERVICE LINE FROM A PUBLIC UTILITY COMPANY TAKES CARE OF ELECTRIC CURRENT REQUIREMENTS WHEN THE ENGINE IS NOT IN OPERATION.





THIS SWITCHBOARD IS LOCATED IN THE PUMP ROOM AND AT THE FOOT OF THE STAIRS WHICH LEAD FROM THE FILTER ROOM AND HEAD HOUSE TO THE PUMP ROOM FLOOR. THIS BOARD HAS MOUNTED ON IT THE INSTRUMENTS AND SWITCHGEAR NECESSARY FOR THE OPERATION OF THE STATION GENERATING UNIT AND ALSO THE SWITCHES AND INSTRUMENTS FOR THE SERVICE LINE. AT THE RIGHT-HAND SIDE OF THE PICTURE CAN BE SEEN THE AUTOMATIC ELEVATOR BOARD.

THIS PICTURE SHOWS WHAT APPEARS TO BE A WORK BENCH IN A LABORATORY. IT ACTUALLY IS ONE OF SEVERAL CONTROL TABLES WHICH ARE LOCATED ON THE OPERATING FLOOR OF THE FILTER ROOM. ON THIS TABLE ARE INSTRUMENTS SHOWING THE RESISTANCE THROUGH THE SAND FILTERS. IN THIS WAY THE RATE AT WHICH THE FILTERS BECOME CLOGGED CAN BE DETERMINED AND THE TIME SET FOR BACK WASHING THEM. ON THIS TABLE ARE ALSO THE VALVE REMOTE CONTROL LEVERS.



been completed the first water to be filtered is allowed to flow into a concrete storage tank, which is located below the filters. Either one of two single-stage house pumps draws the water from this tank and delivers it to three steel storage tanks located on the top floor of the head house, which is that portion of the building between the filter house and the pump room. Each one of these steel tanks holds 10,000 gal. of water. When it becomes necessary to wash a filter, the necessary water is not drawn from the city supply of filtered water, but is drawn from these tanks, which are located high enough above the filters so that a satisfactory head is obtained. The advantage of this arrangement is that the first water to be filtered is not drained off to the sewer and wasted but is used for a purpose for which it is entirely suited.

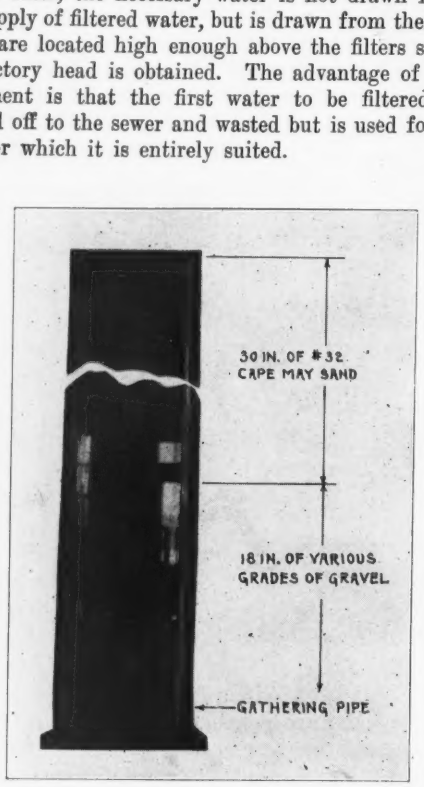


FIG. 7. CROSS SECTION SHOWING METHOD OF MAKING UP A SAND FILTER

It is on an upper floor of the head house that the ground alum, already referred to, is automatically proportioned, mixed with a small amount of water and fed to the water main just ahead of the coagulation tank. This feeder or proportioner, made by the Pittsburgh Filter and Engineering Co., and furnished by the Keystone Machine and Engineering Co., is an interesting device in that it is actuated by water power. The water is first used for power purposes, then the discharge from the water meter is used to dissolve the alum so that here again we find no wastage of water.

To insure further the satisfactory quality of the water pumped to the city, a Wallace & Tiernan Co., Inc., vacuum chlorinator feeds chlorine into the main between the storage reservoir and the pump suction. During the winter months about 2 lb. or liquid chlorine is used per 1,000,000 gal. of water. There are times, however, when it is necessary to use 5 or 6 lb. for the same quantity of water. The amount of chlorine to be used is carefully determined by complete laboratory tests. A check on the quantity of chlorine used is obtained by weighing the chlorine cylinder which is in use. By taking this weight every 24 hr. and comparing the weight used for that length of time with the water pumped for the same period, it is possible to obtain an accurate check upon the amount of chlorination. All water pumped to the city is metered by a Builders Iron Foundry Venturi meter.

The method of sewage disposal from this plant depends upon the level of the water in the Raisin River to which all sewage is discharged. The sewers all drain by gravity during periods of low water. With a high water level in the river, it is necessary to pump the sewage and this is accomplished by a motor driven pump. The foregoing applies not only to the sewage from the main building and filters but also that wastage which settles out in the coagulation basins.

The general scheme of the power end of this new station is that the pump room extends northwest and southeast, one end of the pump room extending under the head house. The boiler room is northeast of the pump room and is so arranged that the firing aisle is at right angles to the long dimension of the pump room. Both of those rooms are on the same level, which is low enough so that water will flow by gravity from the storage reservoir to the pumping units.

From the hallway on the filter room floor level, the visitor goes down a steel-tread stairway to the pump room floor level. At the foot of the stairs is located a General Electric Co. switchboard. Two panels care for the station generating equipment and two panels are equipped with switchgear and instruments for tying in the station with a service line from a public utility company's transmission line. The entire electric load of the station can at any time be thrown on this service line. The station lighting is tied into both the station generating equipment and the outside utility company's line. The elevator, however, is always on the service end of the board.

Just in front of the switchboard is the motor-driven drum and the automatic switchboard of the elevator, which is used to transfer materials from the pump room floor level to the top floor of the head house. The doorways opening into this elevator shaft are equipped with doors which automatically break the circuit when opened so as to eliminate the danger of injury to an operator by the approaching elevator.

Two House Service Pumps Provided

In the northwest end of the pump room are located two motor-driven, single-stage, centrifugal pumps. These are the house pumps and they are so piped that they may be operated singly or in parallel, either to deliver the water from the tanks below the filters to the steel tanks used for storing wash water, or they may be used to deliver the waste water to the river. This latter use is made of them when the water level in the river is too high for natural drainage of the sewer. These are De Laval, double-suction pumps and were designed for a 45-ft. head at 1750 r.p.m. A General Electric Co. induction motor is direct connected to each pump. Located in a corner of the pump room and near the house pump is a vertical sump pump, which removes all drainage from the pump room floor level.

One crank and flywheel pumping unit has already been installed and the order for a second unit has been placed. The second unit will be rated at 5,000,000 gal. per day capacity and is to be furnished by the Murray Iron Works, Burlington, Iowa. With these two units in operation, there will still remain sufficient floor space for a third pumping unit of the crank and flywheel type. The unit

now operating was made by the Worthington Pump and Machinery Corp. It is a cross-compound unit, fitted with releasing Corliss valve gear and is rated at 3,000,000 gal. per 24 hr. The water delivery pressure is 50 lb. per sq. in. ga.

This present pumping unit is of ample size to take care of the week-day load and is also used on the Sunday load; however, it is always advantageous to have certain periods when equipment can be shut down for inspection and repairs. Accordingly, there has been installed a single-stage, motor-driven, double-suction centrifugal pump, which is rated at 2,000,000 gal. per 24 hr. This unit is held as a spare. The pump is a De Laval and the motor was furnished by the General Electric Co. The motor is direct connected to the pump and is rated at 75 hp., 1750 r. p. m., 440 v., 3 phase and 60 cycles. The pump operates against a head of 160 ft.

The electric generating unit referred to in the description of the switchboard consists of an Ames Iron Works uniflow engine direct connected to a General Electric Co. alternator, which is rated at 96 kw., 225 r. p. m., 480 v., 80 per cent power factor, 3 phase and 60 cycles. The exciter is driven by means of a belt from the generator shaft. The uniflow engine operates non-condensing, whereas the 3,000,000 gal. pump and also the proposed 5,000,000-gal. pumping units are each equipped with a water works type of surface condenser. That is, the condenser is placed in the suction line just ahead of the pump, thus, no circulating pump is required. The vacuum pump for this unit is direct connected to the pumping engine, the vacuum maintained being over 28 in. of mercury. The pump room is equipped with a 5-T. overhead crane which is operated by hand.

FIG. 8. LOOKING FROM THE FILTER ROOM THROUGH TO THE FRONT ENTRANCE OF THE BUILDING

Superheaters Are Not Installed

In the boiler room is a battery consisting of two Stirling boilers, each rated at 150 hp. and designed for a pressure of 150 lb. ga. These boilers are not equipped with superheaters. They are fired by Detroit Stoker Co. single retort stokers, both stokers being driven from a shaft, which is chain connected to a 6 by 6-in. Clarage vertical steam engine, which also drives by means of a belt, a Clarage No. 50 forced blast fan, the one fan serving both stokers. This stoker engine is equipped with a Hills-McCanna Co. forced feed lubricator and a Kitts regulator, which varies the engine speed according to changes in the steam pressure. Soot blowers have not been installed, tube blowing being accomplished by means of a steam lance.

Feed water is delivered to the boilers by two duplex steam pumps made by the Union Steam Pump Co. The water fed to the boilers is regulated by hand. Make-up water is taken from the city supply and the boiler water is treated with Magic Compound. The feed water heater is of the Otis closed type, as made by the King Construction Co. Condensate from the pumping unit is returned to the hot well where the make-up is added. The temperature of the feed water is raised to 212 deg. F. in the heater. Low pressure steam available for feed water heating and heating the building comes from the steam driven auxiliaries and the electric generating unit. No high pressure steam is reduced in pressure for heating purposes but a connection is available in case of necessity.

FIG. 9. LABORATORY IS EQUIPPED TO RUN COMPLETE TESTS OF THE CITY WATER

Unlined steel breeching leads from the boiler settings to the radial brick stack, which is 90 ft. high by 5 ft. inside diameter. Indicating draft gages are now being installed on each boiler setting. Ample space remains in the boiler room for additional boiler units. Coal burned at this station comes from the Kentucky and West Virginia fields. It is brought in on railroad cars and dumped from a reinforced concrete trestle into a 15-car capacity storage space. It is then hand-loaded into a small truck and wheeled by hand about 40 ft. to the boiler house, where it is then shoveled into the stoker hoppers.

The personnel on each shift consists of one man in the pump room, one man in the boiler room and a third man in the filter room. The general construction of the building is of concrete, steel and brick, the roof over the boiler and pump rooms consisting of steel trusses overlaid with wood sheathing and pitch and gravel.

City officials having charge of this new development are James Gilmore, Mayor; John J. Marx, Commissioner of Public Utilities, and Geo. W. Brisbin, Superintendent and Manager.

Great care should be exercised when cleaning out the orifices of CO_2 recording apparatus, that the tiny openings are not enlarged during the cleaning process, otherwise the apparatus will not record correctly. In no case should wire or other metallic substance be passed through the apertures; cleaning should be done with a stiff bristle.

Burning Pulverized Petroleum Coke

CHANGING OVER FROM PULVERIZED COAL TO PULVERIZED COKE REQUIRED ONLY MINOR CHANGES TO THE EQUIPMENT

DURING THE WAR period the Oklahoma City plant of Morris & Co., a branch of The North American Provision Co., equipped its boiler furnaces for the use of pulverized coal. This plant being situated near the great oil and gas fields of that district, it has been found expedient from time to time to burn not only coal but also oil and gas, the choice of fuel being based upon price and availability.

Resulting from the process of refining oil is a coke which makes an excellent fuel. This the refineries have screened and found a ready market for the larger sizes. The coke breeze left after screening is not readily marketable unless suitable methods are available for burning it. After a thorough investigation, Morris & Co. decided to make use of its pulverized coal plant to pulverize and burn this refinery coke breeze.

Practically no changes were necessary for the adaptation of the new fuel. Changes that were made, however, were as follows: the air pressure at the screw feeders was cut down to about 0.30 in. mercury and an agitator was installed near the bottom of each hopper which supplies coke to the feeders. These agitators consist of a square shaft, with a suitable bearing at each end, which is chain driven from one of the feeder shafts. Five staggered agitator arms were mounted through the square shaft. The burners had already been moved back 8 in. farther away from the front wall of the furnace, this having been found necessary to keep the flame from eating away the brickwork.

Other than the above changes the preparing and burning plant was not changed. Coke breeze is received in drop bottom cars and unloaded into a covered track hopper located between the boiler room and the fuel preparation plant. A plate feeder discharges the coke to a two-roll crusher which reduces it to about 1 in. size. A bucket elevator then stores the crushed coke in overhead bins from which it is fed to a separately fired rotary type of drier. This drier is fired with coke breeze by hand and, under normal conditions, it is operated about 11 hr. per day.

Coke, having a porous structure, is more easily dried than coal, therefore the fuel cost of drying it is less than for coal. An average load of coke will contain about 6.5 per cent of moisture and after being dried will contain less than 1 per cent of moisture. It has been found at this plant that the pulverized coke is not nearly as susceptible to the absorption of moisture from the air as is coal and little or no trouble has been experienced in handling it in the pulverized form.

After the coke is dried, it is elevated to storage hoppers over the two Raymond pulverizers. Data compiled to date indicates that the serviceability of wearing parts in the pulverizers will be much greater with coke than it was when pulverizing coal. The pulverized coke is separated by air and dropped into the storage hoppers over

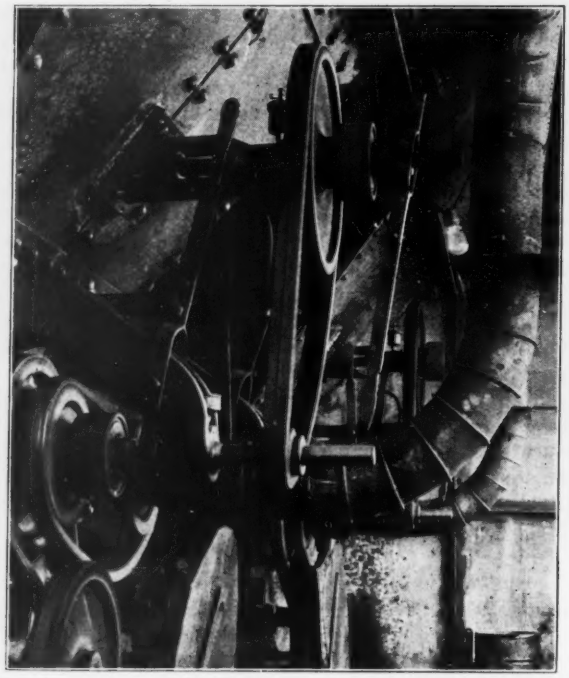


FIG. 1. IT WAS NECESSARY TO INSTALL AGITATORS IN THE FEEDER BINS

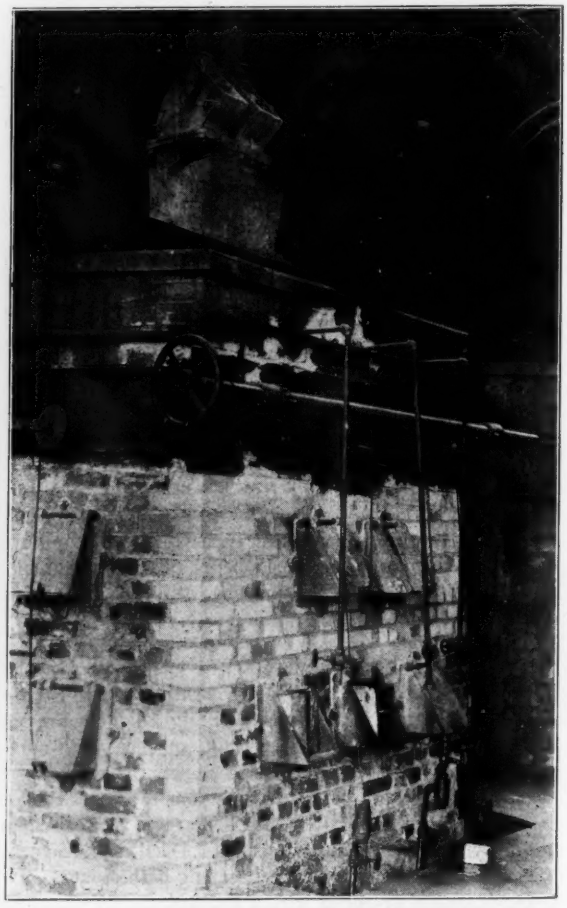


FIG. 2. FUEL IS FIRED DOWNWARD INTO AN EXTENDED FURNACE

the screw feeders. The fineness of the coke is about the same as that required for coal burning. It acts somewhat differently, however, in that it does not run, but has more of the characteristics of lamp black or a paint pigment.

Changes in Air Supply Would Be Beneficial

Two feeders supply coke to each furnace. At the present time the air supply to both feeders comes from a common duct. It is probable that better operating conditions would be had if the air to each feeder could be controlled separately. The feeders are motor driven and variation in speed is obtained by means of Reeves speed changers. An ingenious device installed here is a small d.c. generator, belt driven from one of the feeder shafts. Opposite each furnace at the firing level is an indicating voltmeter calibrated to read in revolutions per minute of the feeder screw. Thus a change in the speed of the feeder, which can be accomplished manually from the operating floor, results in a change of voltage generated which is indicated immediately on the voltmeter. This gives a guide to the fireman as to how much fuel he is firing.

Each furnace is equipped with two burners which discharge the fuel downward into an extended or Dutch oven type of furnace. The combustion space is 11 ft. 6 in. from front to back by 17 ft. deep, giving a combustion space of 1485 cu. ft. Each boiler is rated at 4680 sq. ft. The furnaces are under natural draft, the suction in the combustion space being kept about 0.04 in. water, or practically a balanced draft. Air admission doors are arranged around the furnace front and through them is admitted the rest of the air needed for combustion. Most of the air, not admitted with the fuel, enters the furnaces at the bottom below the shelf in the extended front. This shelf is not desirable and it is planned to remove it.

Some trouble results from ash fusion on the bottom of the furnace. This difficulty will be overcome when the furnaces are rebuilt and equipped with a water screen as shown in Fig. 4. The ash content of this coke is generally about 3¼ per cent and therefore the quantity to be removed from the furnace is small and it has been found that practically no ash is discharged up the stack. In this respect the coke is a much more satisfactory fuel around a packing plant than was the pulverized coal.

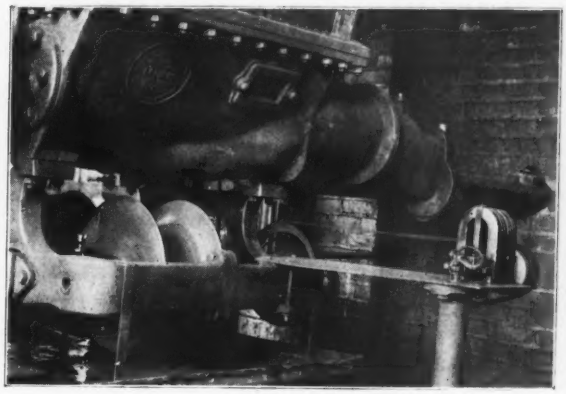


FIG. 5. GENERATOR, BELTED TO FEEDER SHAFT, USED TO INDICATE SPEED

Clay in Coke Was Troublesome

Trouble was experienced for a time with a soft honeycombed substance which gathered on the 3rd and 4th rows of tubes. If allowed to accumulate it would in time interfere seriously with the draft. An investigation revealed that the trouble was not due to firing coke but was caused by clay which was picked up with the coke when it was being loaded at the refinery. It has also been necessary to insist that cars which had been previously loaded with gravel be swept clean before the coke was loaded. If the cars were not cleaned a certain amount of gravel would of necessity pass through the crusher and have to be pulverized with the coke.

A small amount of oil is stored at the plant and each boiler is equipped so that three burners can be attached on short notice.

On Oct. 24, 1924, a short time after the change was made to pulverized coke, the following results were obtained on a test, the duration of which was 12.7 hr.

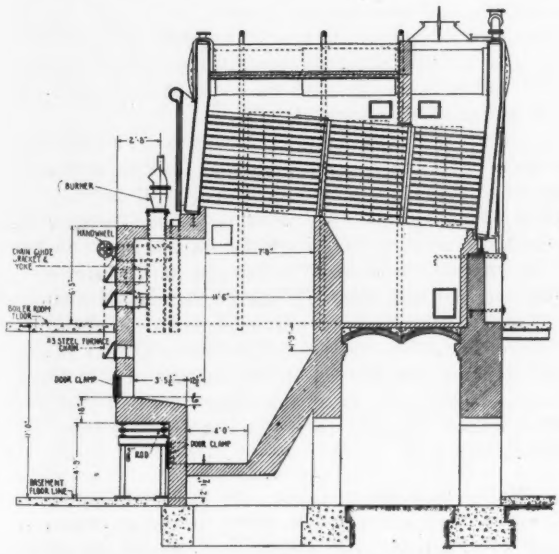


FIG. 3. FURNACES WERE BUILT WITH A SHELF BELOW THE ARCH

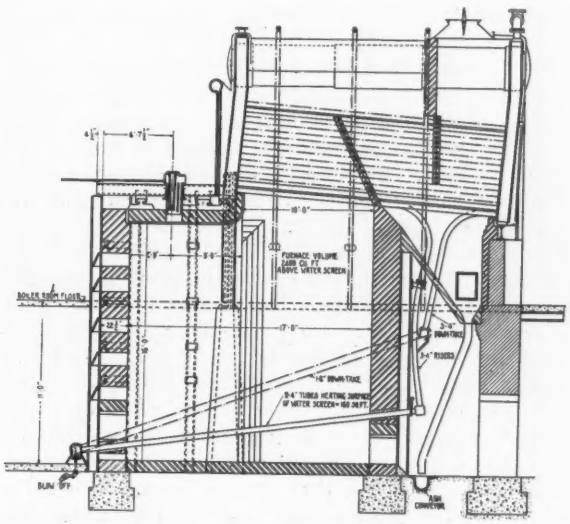


FIG. 4. CHANGES TO THE FURNACES WILL PROVIDE GREATER COMBUSTION SPACE AND A WATER SCREEN

Fuel used	Petroleum coke breeze
Water heating surface, sq. ft.	4680
Volume of furnace, cu. ft.	1485
Proximate analysis of coke, as received—	
Moisture, per cent	6.51
Volatile carbon per cent	14.19
Fixed carbon per cent	76.01
Ash, per cent	3.29
Sulphur, per cent	1.87
B.t.u. per lb.	13,800
B.t.u. per lb. dry	14,761
B.t.u. per lb. of combustible	15,300
Water evaporated, total actual, lb.	198,770
Quality of steam, per cent	98.6
Factor of evaporation	1.134
Per cent rating developed	109.9
Water evaporated, F. & A. 212 deg. F. per lb. fuel as received, lb.	11.27
Water evaporated, F. & A. 212 deg. F. per lb. dry fuel, lb.	12.06
Water evaporated F. & A. 212 deg. F. per lb. combustible, lb.	12.49
Air pressure on feeders, in. Hg	0.30
Steam pres. lb. ga	135.2
Draft suction at uptake, in. H_2O	0.080
Gas analysis, first pass—	
CO_2 per cent	14.5
O per cent	4.6
CO per cent	0.0
Gas analysis, flue—	
CO_2 per cent	13.6
O per cent	5.6
CO per cent	0.0
Heat absorbed by water in the boiler, per cent	79.24
Lb. fuel fired per b.hp. hr.	3.06

During the run of this test the rating and draft conditions were frequently changed to observe the various conditions and requirements of the fire. Ratings up to about 160 per cent can be obtained with the present arrangement of furnace.

Changes Will Be Made to Furnaces

Plans are now under way, whereby the furnaces will be brought out square and extended straight down to the basement floor. Each 468-hp. boiler will also be equipped with a water screen which will contain approximately 160 sq. ft. of heating surface. These contemplated changes are shown in Fig. 4. It is expected that this will result in higher ratings being obtained and also more satisfactory operation under the existing conditions of a widely fluctuating load.

As a possibility for the use of still another fuel at this plant, the engineers are investigating the burning of refinery residue by means of steam atomization. The steam will be obtained from a separately fired superheater.

Recently a Western gas utility made a large number of tests on cast and malleable iron pipe fittings varying in size from 1 in. to 4 in., including tees, crosses, elbows, etc., in order to determine the number of fittings that contained leaks. Results of these tests showed that out of several hundred fittings tested, approximately 50 per cent showed leaks. The fittings were taken at random from stock shipments and the results obtained were undoubtedly representative of the average small fittings that are on the market today. The manner of testing these fittings is interesting. A test machine was rigged up in which the fittings were clamped, six at a time in a row, held in place by air cylinder plungers which terminated in rubber buffers. In the center of the buffers were holes through which air at 60 lb. pressure was forced into the fittings as they were held fast by the pneumatic plungers. A trough of water was then arranged so that it could be raised over the fittings. Any leaks in the fittings were then immediately discernible by the formation of air bubble streams from the flaw.

Jerky Engines

By N. G. Near

IT IS OFTEN asserted that to prevent lamp flicker or severe jolts, the belt connecting the jerky engine and the driven generator or other machine should be allowed to slip slightly.

There was a time, when the jerky gas and gasoline engines first came out, that some belt slip in a generator drive was considered necessary. But not so today. Granted, of course, it is better to allow the belt to slip a bit than to have a flicker in the lights every time an explosion occurs. If the engine is already built and installed it may be difficult to remedy poor regulation and then I will agree that it may be all right to "Let 'er slip."

No engine, however, should be allowed to go out of its factory with so light a flywheel that the change in velocity with each explosion will be visible to the *naked* eye via the intensity of the electric lights. It is a comparatively simple matter to design a flywheel so that it will take care of lights without flickering and without requiring the belt to slip. I will not take the space to show how flywheels should be designed, but for any reader who is interested I would suggest reading up on that subject in Goodwin's "Mechanics Applied to Engineering." Goodwin goes into it ably, simply, and thoroughly. After you have finished with that chapter you will be able to design a flywheel for a gasoline engine which will insure the lights burning without a flicker although the engine may have only two explosive strokes per minute. The flywheel will be large but it will do the work without belt slip.

Several years ago I was in a small town in the West, putting up at the only hotel there. I noticed the lights flickering. Sticking my head out of the window I could hear the village producer gas engine exploding away at regular intervals and with each explosion there was a distinct flicker. I took enough interest in the matter to go over to the small plant and engage the engineer in conversation. He thought the flicker simply "had to be" and that it couldn't be stopped. I argued otherwise, however, and soon convinced him that if he would put a flywheel of some kind on the dynamo shaft, and make it heavy enough and strong enough to withstand centrifugal force, he could stop the flickering. He said he would try it. I learned since, through an acquaintance, that he did it and that the flickering stopped.

A little belt slip isn't bad, perhaps, but I would rather do away with it entirely if possible. Just as soon as one begins to tolerate a little slip here he will tolerate more there. Finally, before we know it, we are unconsciously permitting all sorts of evils which in the long run prove to be extremely expensive. I, for one, am in favor of cutting out the little losses. Thus in the case of a slipping belt on the generator, every time the engine explodes there is a considerable power loss. The loss is greater than the ordinary slip loss because at the instant of slip the belt tension is greater than at any other time and that useful effort is lost. Besides, there is the more rapid wear in the belt and its cost.

Water hammer in steam lines is caused by improper draining of the lines, and in severe cases may cause a rupture of the line. All steam lines should be properly drained, properly hung or supported and adequate provision should be made for expansion and contraction.

Wood Waste Used as Fuel for Power Plants*

PHYSICAL CHARACTER AND HIGH MOISTURE REQUIRE SPECIAL FURNACE DESIGN FOR BURNING HOGGED REFUSE IN THE LUMBER INDUSTRY

UTILIZATION of wood waste from the lumber-manufacturing industry as a fuel for power-producing purposes offers to the engineer a series of problems as unique in character as they are important in their economic scope. The yearly output of such waste actually employed to produce power in the Pacific Northwest is the equivalent of about 2,000,000 T. of good steam coal or 7,000,000 bbl. of fuel oil. The intrinsic heating value is low and its bulk, high moisture content and irregular texture call for the solution of difficult problems in handling, storing and firing, with equally important questions in furnace design, draft control, and cinder elimination to be solved. The present efficient types of furnaces used with this fuel are the result of a long period of evolution, wherein its peculiar nature was studied in relation to known principles of combustion. This resulted in the development of a distinct and characteristic line of engineering methods which have fostered the design and operation of wood-waste burning plants having an efficiency and capacity comparing favorably with other steam power plants.

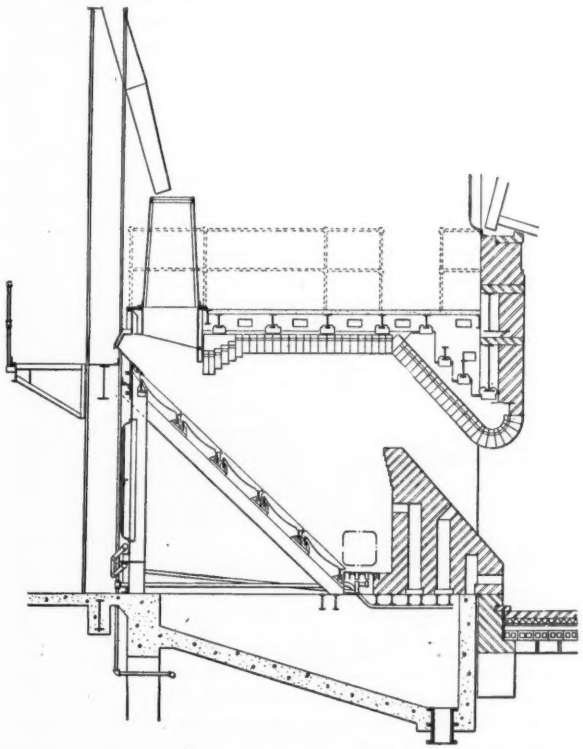


FIG. 1. SLOPING GRATE FURNACE WITH STANDARD GRATE BARS

In this industry, in general, there has been a larger amount of waste material than needed for the production of power, therefore efficient combustion has been of little importance. But the general demand for electrically operated mills and the installation of modern equipment for this purpose has caused the need of higher steam pressures, compact boiler rooms, more efficient fuel handling and combustion methods.

WASTE MATERIAL PROVIDES LARGE SOURCE OF FUEL

Wood waste from lumber manufacturing industries is commonly referred to as "hog fuel." Actually, this is correct only when applied to certain specific conditions, but in general, may be applied to all waste. In the parlance of the lumber industry a unit of hog fuel is equivalent to 200 cu. ft.

It can be conservatively assumed that the mills will average one-half unit per 1000 ft. of lumber produced. Because of its bulk per unit of heat and the difficulty in handling, the price obtained by the mill is a comparatively small percentage of its cost delivered at the boilers. But new methods of handling and more effective combustion have made profitable the use of this material as fuel.

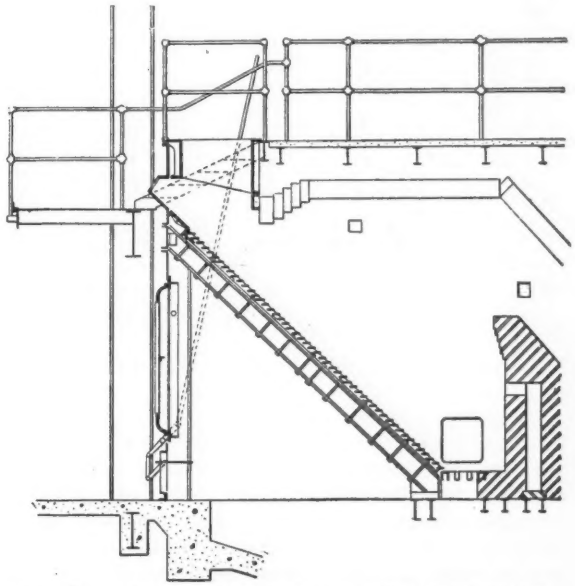


FIG. 2. SLOPING GRATE FURNACE WITH STEP GRATES

CHARACTERISTICS OF FUEL MAKE SPECIAL FURNACE DESIGN NECESSARY

Physical character of the fuel and the high moisture content have made special design of furnaces necessary. In general, the design of hog fuel furnaces has undergone considerable change in recent years. Originally wood refuse, was fed through openings on the two sides of the shell of return tubular boilers, immediately in back of the front wall of the boiler. This meant that the combustion took place immediately under the shell of the boiler, and as the fuel piled up against the side walls there was comparatively little brickwork to radiate heat onto the green fuel as it came into the furnace, and the cold shell of the boiler absorbed heat rapidly through radiation. Under such adverse furnace conditions the capacities obtained were comparatively low, the efficiency was poor, and the boilers smoked badly.

* Abstract of papers presented at A.S.M.E. meeting at Portland, Oregon, June 22-25, 1925, by H. W. Beecher, C. C. Simeral and C. L. Young.

The next step was the use of Dutch-oven furnaces where the fuel was fed through openings in the arch. In this type of furnace the conical pile or piles formed on the grate do not extend up furnace side walls, so it provides larger exposed areas of hot brickwork. Automatically the length of gas travel was increased and a portion of the green fuel was shielded by brickwork from direct radiation of heat to the cool surface of the boiler. The extension furnace also permitted the use of a larger grate

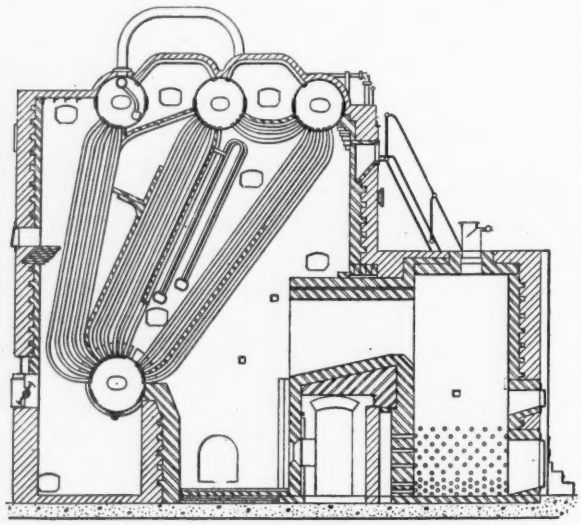


FIG. 3. STIRLING BOILER WITH HEARTH-TYPE FURNACE AND PROVISION FOR AUXILIARY OIL BURNERS

surface and in general allowed for greater latitude in proportioning it.

The next progressive step in furnace design was the addition of a drop nose or curtain wall located at the inboard end of furnace arch. The purpose of this drop nose was further to shield the green fuel bed from boiler tubes, provide additional incandescent surface for reflecting heat on the fuel pile and the issuing gases, and to direct the gases downward into the combustion space beyond the bridgewall. As the products of combustion from wood refuse occupy a comparatively large volume per developed B.t.u., high velocities are obtained through the furnace and it is advisable to change the direction of these gases so that they will not short-circuit into the tube surface. The drop-nose furnace, if properly designed, will accomplish this deflection and utilize to the greatest extent the combustion space, not only securing greater actual length of gas travel between fuel bed and boiler surface, but also in effect increasing the time the gases are in transit over and above that proportional to the length of travel.

There are many cases of furnaces installed where the designers have noted the excellent results obtained with the drop-nose arch but have not appreciated the full purpose of such construction as they have installed the drop-nose in front of the bridgewall.

About five years ago, the inclined-grate furnace as used in the Hawaiian Islands for the purpose of burning bagasse was considered as a possible design for the efficient combustion of hog fuel. This type of furnace is fitted with "step-grates."

A study of the analysis of bagasse, or sugar-cane refuse, and a comparison of it with the average sample of hog fuel show that they each contain approximately the same number of B.t.u. per lb. dry. They both carry about the same moisture content, and the effect of the resin content of the wood refuse is about offset by the effect of the sugar remaining in the bagasse. This gave the conviction that such furnace construction, with slight modification, was adaptable to the burning of wood refuse and that its use would permit of obtaining higher capacities and better efficiencies.

In the latter part of 1922, experiments with a furnace of this construction burning waste from a wood-preparation plant, were conducted at a large paper-mill plant under 350-hp. Babcock & Wilcox boilers, and comparisons made with a standard dutch-oven type of furnace. The wood waste at this plant runs from 55 to 60 per cent moisture and the experimental results obtained from this furnace indicated its worth for burning high-moisture fuel. The paper company at that time was installing a new boiler plant with 500-hp. units, and one of these boilers was fitted with the new type of furnace. Six months' operation showed sufficient savings from the use of this furnace design to warrant installing it on two additional boilers. Figure 1 shows one of these furnaces now used at a paper-

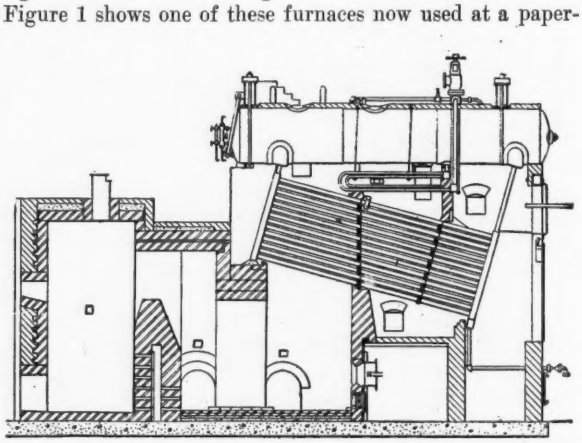


FIG. 4. BABCOCK & WILCOX BOILER WITH HEARTH-TYPE FURNACE AND PROVISION FOR AUXILIARY OIL BURNERS

mill plant and fitted with standard grate bars set at an angle of approximately 45 deg. from horizontal.

Figure 2 shows an inclined furnace with step grates installed under the other boiler of the battery.

Recently two boilers fitted with these furnaces were put into successful operation at the plant of the Mountain States Power Co. at North Bend, Oregon. These furnaces have several advantages over the flat grates.

Factors Governing Combustion

The fuel is fed across the entire face of furnace and drops down over the grate area in a blanket of more or less uniform thickness. The ordinary method of burning fuel in conical piles on flat horizontal grates means that the central portion of the fire is too thick and the outside edges too thin for the most economical results. It also makes necessary the supplying of most of the air required for combustion by the overdraft method, due to the greater portion of the fuel on the grates being burned on the surface of the cone. In the step-grate furnace the upper portion of the fuel bed forms a distillation zone in which the volatiles and moisture content are rapidly driven off. The lower portion of the fuel bed is a mass of incandescent carbon through which the air is readily drawn, due to its open or porous nature. The process of combustion

approximately consists of the uniting of air with the incandescent carbon to form the dioxide, which in turn, in passing through the remaining portion of the fuel bed, takes up carbon, to be reconverted into the monoxide. Secondary air is admitted through tuyeres in the bridgewall and unites with the monoxide gas as it leaves the incandescent fuel bed to be reconverted to the dioxide. This secondary air also unites with the volatile gases driven from the upper portion of the fuel bed and the furnace becomes in effect a combination of a gas producer and a gas-burning retort. The drop nose on the inboard end of the furnace deflects these burning gases downward, allowing long gas travel before they reach the tube surface and insuring complete mixing and combustion of the gases.

Stationary Grates More Effective

With properly designed step grates there is no riddling of cinders or fuel into the ashpit. The slag which forms on the grate can be removed by slice bar between the grate openings with the plant in operation. The dump gates can then be utilized to clear the furnace of slag.

A hopper is constructed across the face of the furnace in which the fuel will form a seal, preventing the admission of excess air. The secondary air supply can be separately regulated to correspond with the rate of combustion desired.

It is believed that this furnace will be used to a considerable extent in refuse burning, where efficiency and capacity are of importance.

Another development of a high-efficiency furnace is known as the "hearth" furnace, and is illustrated in Figs. 3 and 4. As shown, these furnaces are fitted with special combustion chambers and mechanical oil burners for supplementing hog fuel with oil.

This furnace construction requires forced-draft fans and ducts and does not use any grates. The slag which accumulates can be drawn off the bottom of the furnace through the clean-out door provided.

With the "hearth" furnace, favorable CO_2 percentages and efficiencies can be obtained. It offers some advantages over the step grate furnace in that there are no grates to maintain.

Many attempts have been made to burn hog fuel on mechanical stokers. The logical stoker for this purpose would be the traveling or chain grate if it were not for difficulties that develop in practical operation. The shreds and sticks that are ever present in hog fuel interfere with uniform feeding of the fuel from the stoker hopper on to the traveling grate. Lack of uniformity in compactness with which the fuel lodges on the grate, as well as variation in its thickness, allows blowholes to develop through the fuel bed as soon as the fuel loses its volatile content. Such blowholes are responsible for excess air and low carbon dioxide content of the flue gases. Experiments tried with stokers of the underfeed type have also developed mechanical difficulties in the feeding of fuel, due to shreds and sticks.

The step-grate furnace, as earlier described, is an approximation to the overfeed stoker, depending entirely upon gravity and without agitation. Experiments have been made with agitation of fuel bed, without improvement in results, and the dry, partially consumed cinders, if agitated, have a tendency to lift from the grates.

The quality of hog fuel, both in consistency and moisture content, varies over a wide range, requiring that constant attention be given to the regulation of the fuel supply in the furnace, as different grades of fuel require changes in the volume of fuel carried in the furnace. With very coarse fuel, containing a large amount of long sticks and bark, it is necessary to maintain a thicker fuel bed than when the fuel is properly hogged, since the sticks and bark will not "avalanche" or flow to cover the grates as readily as the well-ground fuel, consequently a thicker fuel bed must be maintained to insure the grates being properly covered.

With a decrease of the moisture content the volume of fuel in the furnace may be increased without making necessary an increase in draft to maintain a given boiler output. With the type of furnace shown in Fig. 5 the experience of the Portland Electric Power Co. has demonstrated the necessity of so locating the fuel holes that the thickness of the fuel bed will be at least 18 in. at the bridgewall, while at the front of the furnace the fuel will taper down to a "feather edge." The application of the

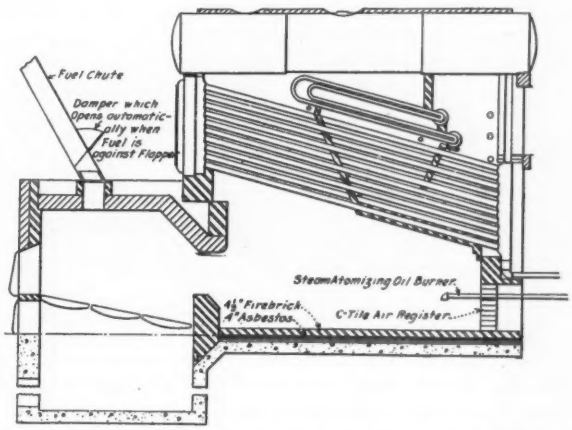


FIG. 5. FURNACE FOR HOG FUEL AT PORTLAND ELECTRIC POWER CO.

above principles to the regulation of the amount of fuel in the furnace tends to increase efficiency and capacity.

Continuous fuel feeding, rather than intermittent feeding, also increases the efficiency and capacity of the furnace, since with the fuel supply regulated to conform with the rate of combustion, there results more uniformity in furnace temperatures and draft conditions, and consequently better boiler output. The advantages realized make its use quite attractive as a matter of economy, due to the direct saving in operating labor and fuel and the indirect saving in furnace maintenance.

Air and Draft Control Important

Hog fuel burns on the surface of the fuel bed in the furnace, which, under certain conditions, requires that a portion of the air for combustion be admitted at the front of the furnace above the grates. The amount of air admitted above the grates will vary from 0 to 20 per cent of the total air required for combustion, depending on the type of furnace and quality of fuel. The lower the moisture content of the fuel the higher the percentage of air admitted above the grates. The admission of air to the furnace above the grates at points other than the front of the furnace does not give satisfactory results for combustion control, and experience has indicated that such procedure is detrimental to economy and efficiency.

Proper draft regulation is one of the prime factors in burning hog fuel successfully, as the draft must vary over

a wide range to compensate for the rapid changes in the moisture content of the fuel as well as the varying depths of the fuel bed. The importance of this latter factor can readily be appreciated when it is realized that the draft resistance of the fuel bed will vary over three or four times the variation range usually encountered in a well-regulated stoker-fire coal-burning plant. Due to the necessity of properly meeting these draft conditions, automatic control of mechanical-draft equipment quite naturally is in position to play an important part in the efficient combustion of hog fuel.

Figure 5 shows a hog-fuel setting applied to a 450-hp. Stirling type water-tube boiler with a grate ratio of 1 to 3.1. This is made large on account of burning wet redwood with about 60 per cent moisture.

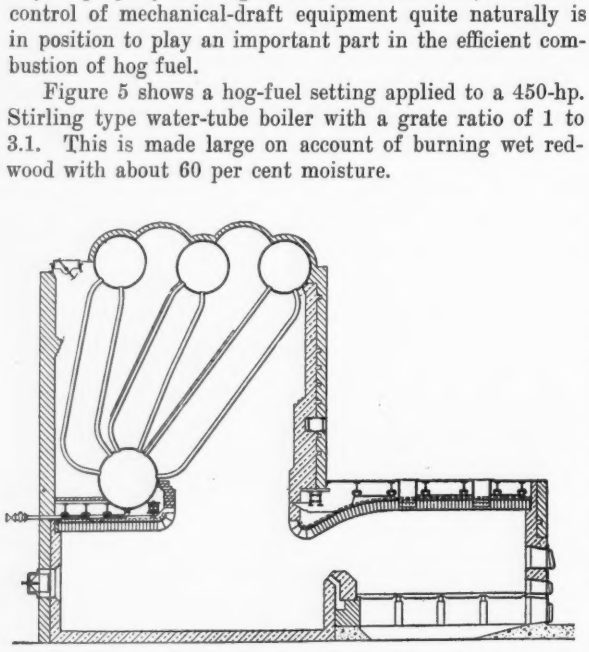


FIG. 6. EXTRA LONG DUTCH OVEN TYPE SETTING FOR STIRLING BOILERS

The dutch oven proper, or the portion of the setting ahead of the bridgewall, may be considered as a retort for the destructive distillation of the wood. The volume over the grates is not sufficient to permit complete combustion and it is here that the combustible gases are driven off the fuel. It follows, then, that beyond the bridgewall a combustion space must be provided for the burning of these gases and also such solids as are carried over by the draft. Secondary air is usually provided in the combustion chamber in order to complete combustion. In Fig. 6 a hollow bridgewall is shown for this purpose. Air ducts at about 12-in. centers emit air to the combustion space normal to the gas stream, the idea being that this air jetted into the gas stream will properly diffuse with the gases. In this setting a very long flame travel has been obtained, thus insuring complete combustion before gases strike the heating surface of the boiler.

Chemicals in Ash Cause Brickwork Difficulties

With wood refuse containing from 40 to 50 per cent of moisture there is little difficulty to be expected with brickwork attributive entirely to high temperatures, as the high moisture content precludes the possibility of obtaining excessive temperatures with this fuel. Many temperature observations in various plants throughout the Northwest by means of an optical pyrometer have showed that 2300 deg. is seldom exceeded. Furnace temperatures are usually below 2000 deg., and frequently observations have shown as low as 1600 deg. Where either mixed fuel or fuel from dry kilns is used slightly higher temperatures are obtained, but in none of the cases observed have temperatures been indicated that would cause undue deterioration to the refractories used. There are, however, kindred difficulties that develop, due to the fluxing of the refractories by the chemical effect of the ash contents and the gases given off in combustion of wood refuse. Many of the sawmills receive their logs after they have been in salt water. The wood absorbs varying percentages of moisture from the water in which it lies for indefinite periods of time, and the salt in the wood refuse (much of the wood refuse is from exterior portions of the log) causes a salt glazing or fluxing of the exposed surface of the firebrick. In addition to this, there is always present more or less lime in the ash. This comes in part from stones and shells put into the furnace with the bark.

If a log has become teredo-eaten, this adds materially to the lime content of the wood refuse, as each teredo bore contains a thin lining of calicum carbonate, which is calcined in the furnace. Analysis of ash has shown as high as 58 per cent calcium oxide. There have been very few analyses with which the author is familiar that have not shown a material percentage of iron oxide. Calcium and iron are both violent fluxes to fire-clay brick made of normal mixture of oxides of aluminum and silicon. It is the combination of the chemical action of these fluxes and a medium temperature that produces the glazing and running of the furnace linings. The furnaces as a whole do not deteriorate by abrasion, but there is usually some abrasive effect along the side walls and also around the feed hole through which fuel is admitted to the furnace. This calls for frequent local repairs.

With the comparatively low temperatures obtained, spalling in wood-refuse furnaces is not marked, and the brickwork difficulties can in general be largely attributed to the chemical or fluxing action of the constituents of the ash.

Cinder Elimination by Fans

Elimination of the cinders from the flue gases discharged from hog-fuel plants is required in some localities, especially where these plants are located within the corporate limits of municipalities. Both "cindervane" fans and "cyclone" dust precipitators are used for this purpose, the dust precipitators having proven more effective and reliable to date. Disposal of the soot and cinders is accomplished by sluicing them to the ash dump. Conveying them back to the furnace would naturally seem the proper procedure, but with the large amount of ash collected with the soot and cinders, rapid formation of clinkers on the grates results, which more than offsets the advantage of reclaiming the available B.t.u. in the cinders.

Clinker formation on the grates depends to a large extent on the amount of sand and silt that finds its way to the furnace from the bark on the logs. Consequently, the nature of the soil formation where the logs are procured, as well as the method of transporting the logs, has a direct bearing on the clinkers formed on the grates. The sand and silt unite with the wood ash and fuse to the grate bars. If the clinker is not immediately removed it forms a solid mass over every portion of the grate surface. The grates used in the plants of the Portland Electric Power Company are of the common rib bar type with 5/8-in. air openings, and yet they must be thoroughly cleaned after the consumption of one unit of fuel per square foot of grate surface.

Modern Condensing Practice in Great Britain

SURFACE CONDENSERS, PARTICULARLY WHEN USED WITH TURBINES, ARE MOST WIDELY FAVORED. BY C. H. S. TUPHOLME

ON ACCOUNT OF the present high cost of fuel in Britain, efforts are being concentrated upon producing power plants where the energy of the steam is employed to the highest possible degree and in the last few years great improvements have been made by the use of steam of high pressure, high superheat, and by reducing to the minimum the counter pressure in the exhaust. In addition it has been recognized that an up-to-date and carefully designed condensing plant is essential if the highest efficiency is to be obtained in a steam power station, especially if steam turbines are used.

British power plant engineers, both in central stations and in industrial manufacturing plants, are favoring, to a greater degree than ever, the steam turbine, which has a great advantage over the piston steam engine in that it can utilize high vacuums, reaching 98 per cent, which can nowadays be obtained without difficulty, while the piston engine can seldom advantageously use a vacuum exceeding 85 per cent unless its dimensions are greatly increased.

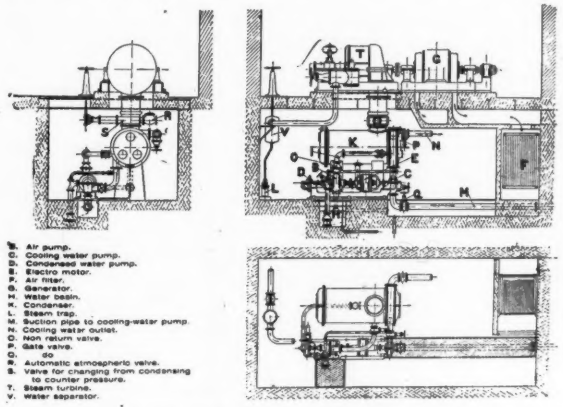


FIG. 1. STEPS IN CYCLE OF OPERATION OF A SURFACE CONDENSER

SURFACE CONDENSERS MOST POPULAR

Popularity of the surface condenser in Britain is no doubt due to the fact that the condensed water does not come into contact with the cooling water and therefore does not affect the condition of this water. Though this type of condenser is the most expensive to install, it has been found the most economical in service. The quantity of cooling water required varies from 40 to 70 times the weight of the condensed steam.

An arrangement usually adopted by plants in Britain is shown in Fig. 1. K is the surface condenser, usually located directly beneath the exhaust of the steam turbine in order to reduce to the minimum the pressure losses in the exhaust pipe. The pipe is sometimes provided with a gate valve S and always with an automatic exhaust valve R, which discharges to atmosphere. The exhaust valve R opens as soon as the pressure in the exhaust pipe rises above atmosphere. This exhaust pipe is customarily provided with an expansion piece between the steam turbine and the condenser, the object being to prevent distortions on account of heat stresses.

Circulating water Pump C sucks the cooling water through the pipe M, forces it through the condenser, from which it is drawn off through the pipe N. In case this outflowing water is led to a cooling tower, this discharge pipe is equipped with a gate valve P. Between the pump and the condenser a gate valve is inserted for the regulation of the cooling water supply. B is a rotary air pump which removes the air in the condenser through the pipe I. The water, essential for the operation of the pump, is drawn up by the pump itself from the well H, into which the mixture of air and water is delivered. O is a check valve which prevents the water in the well H from being sucked up into the condenser should the air pump be out of order. The centrifugal pump D sucks the condensed water from the condensers and delivers it through a flap valve to a feed water tank, located above the floor line of the condenser cellar.

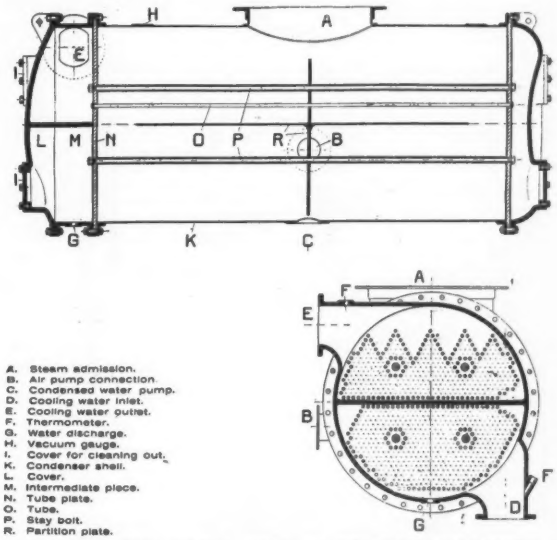


FIG. 2. STEEL SHELL TYPE OF SURFACE CONDENSER

One type of surface condenser greatly favored in both small and large plants is that shown in Fig. 2. The condenser shell is of steel, and is provided with an intake for the exhaust steam from the steam turbine and the other essential openings. This type is giving excellent results in many plants in Europe.

Another favorite type, especially in British plants, is the shallow boat-shaped type illustrated in Fig. 3.

At the Pinkston power plant at Glasgow is the surface condensing plant shown in Fig. 4. This is one of the most recent installations in the British Isles. This plant operates in conjunction with a 10,000-kw., 1500-r.p.m. turbo generator and, while the normal steam duty is 125,000 lb. per hr., the condenser has been designed to cope with a heavy overload and to be capable of maintaining a vacuum of 27.8 in. with cooling water at 75 deg. F., when dealing with 185,000 lb. of steam per hour. At normal full load the plant is guaranteed to give a vacuum of 28.3 in. with circulating water passing through the tubes at the rate of 19,200 gal. per min. A cooling surface of 19,000 sq. ft. is provided by solid drawn brass tubes of

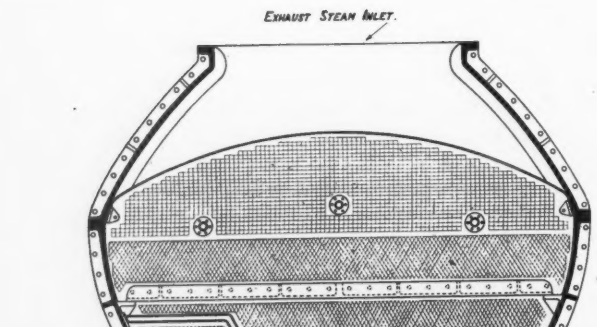


FIG. 3. SHALLOW BOAT-SHAPED TYPE OF SURFACE CONDENSER

2. Lowest possible temperature difference between the entering steam and the condensate.

3. Minimum of power absorbed in circulating the necessary quantity of cooling water through the condenser.

The importance of these factors may be judged by the following considerations:

Item 1. A reasonable figure for pressure drop, or the difference in vacuum or absolute pressure at the steam entrance from that at the air pump suction could be taken as 0.15 in. mercury. If, however, this pressure drop were doubled, it would be equivalent to a loss of around 0.9 per cent in the steam consumption, or, for a 10,000-kw. turbine, equivalent to a loss of 1,080,000 B.t.u. per hour.

Item 2. A reasonable figure for this would be a difference of 3 deg. F. If this temperature were doubled then for a 10,000-kw. turbine it would represent a loss of around 360,000 B.t.u. per hr.

Item 3. Assuming 28.5 in. vacuum with a water inlet temperature of 70 deg. F., a reasonable difference in temperature between the entering steam and the outlet condensing water would be 6 deg. F., but supposing again this figure were doubled, it would mean that more condensing water was being circulated, and the loss for a 10,000-kw. turbine might be anything up to 1,500,000 B.t.u. per hr. The exact figure would, of course, depend upon the head against which the condensing water had to be pumped.

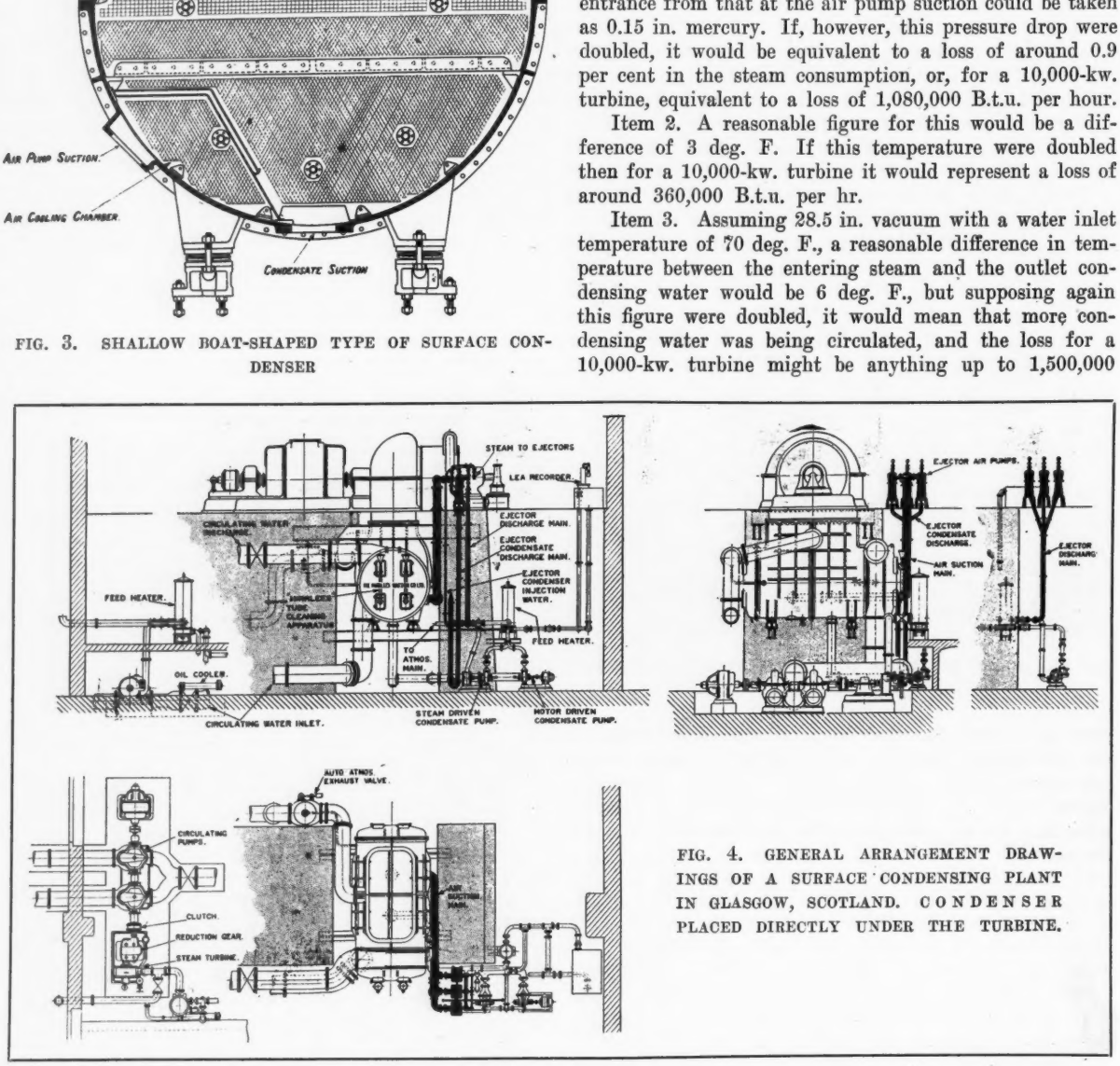


FIG. 4. GENERAL ARRANGEMENT DRAWINGS OF A SURFACE CONDENSING PLANT IN GLASGOW, SCOTLAND. CONDENSER PLACED DIRECTLY UNDER THE TURBINE.

¾ in. diameter and a thickness of 18 by the British standard wire gage. The velocity of the water through the tubes is 6.1 ft. per sec., and the rate of heat transmission is practically 630 B.t.u. per deg. F. difference of temperature.

Selection of Condensers Influenced by Pressure and Temperature

The three most important requirements from the purchaser's standpoint in the operation of surface condensers are:

1. Lowest possible pressure drop across the steam space.

The accumulation of scale in the throat of a Venturi meter tube decreases the area of the passage, thereby increasing the velocity of the fluid through it which causes the meter to register high.

To find quantity of water elevated in one minute, running at 100 ft. of piston speed per minute: Square the diameter of the water cylinder in inches and multiply by 4.

Mechanical Features of Hydroelectric Plants*

FLASHBOARDS, TRASHRACKS, RACK RAKES, SLUICE AND HEADGATES, PENSTOCK VALVES AND AIR VENTS AFFECT ECONOMY AND RELIABILITY OF OPERATION. BY E. A. DOW

PERHAPS THE MOST logical way to handle the discussion of a series of more or less disconnected items is to commence with those features pertaining to dam or intake and follow along downstream with the water. This introduces us to one of the most difficult and perplexing subjects first; namely, spillway-crest control. Devices in general use include simple flashboards supported by pipes or pins designed to bend over and clear the crest when the water surface reaches a predetermined elevation, rather elaborate arrangements balanced hydraulically with a change in water level and crest gates of the sector or sliding type which depend entirely on the human element for their operation.

With the exception of those for the storage developments, all the spillways of the New England Power System are equipped with the simplest type of flashboards, ranging in height from 4 to 8 ft., and in one case even 10 ft. The boards are supported by steel pipes of various sizes, weights, and grades, selected to suit individual conditions, and it has been found that failure takes place with satisfactory consistency at the desired pond elevations. When there is sufficient warning of an impending flood, boards are removed, otherwise they are allowed to go and are lost, which occurs on an average of probably once a year. Satisfactory tightness is maintained by calking with cinders, which may seem somewhat surprising, but the flashboards are assembled in sections, which aids in this respect.

At Somerset and Davis Bridge conditions affecting flashboards are materially different from those at other plants. The large storage capacities in the upper levels of the reservoirs eliminate the possibility of a dangerously sudden rise in water elevation and on account of the great value of the stored water it is out of the question to draw down materially to replace flashboards after a flood. A control is required which can be replaced with a considerable depth of flow over the crest, yet it must be of such a type that it can be removed with certainty, by one man if necessary, in spite of ice.

*Obtained from paper read at spring meeting of A.S.M.E.

SLUICE GATES SHOULD BE PROPORTIONED TO DRAINAGE AREA

Either surface or submerged sluices can be used and both have certain advantages but for handling fairly large flows the submerged type ordinarily proves the more economical. Discharge may take place directly into the air or below tailwater. The first arrangement permits of convenient inspection for leakage, while the latter is less subject to trouble from freezing. The commonest kind of submerged sluice consists simply of a cast-iron frame and sliding gate provided with a screw stem and mechanical hoist, or with a pressure cylinder. The latter is much to be preferred when the operating mechanism is located in a damp place, as in a gallery in a dam, because a mechanical hoist, particularly if electrically operated, is extremely difficult to keep in proper maintenance under such conditions.

A typical installation of this kind is illustrated in Fig. 1. The hoist capacity had been figured on too low a friction coefficient and the hoists were overworked. The stems were correspondingly light and had probably been designed on the assumption that since they were made of bronze having the same tensile strength as steel they would be equal to steel as columns, no attention being paid to the effect of a much lower modulus of elasticity. Several of the stems buckled. The gates themselves gradually sagged and warped under the load and one of them finally failed and went out altogether, leaving the sluice wide open.

From the Vernon experience several things were learned of general application in connection with sluice-gate installations. Among these are: (1) That it does not pay to economize on first cost by using light sluice-gate equipment. (2) Designs should be based on a coefficient of sliding friction of at least 0.75. (3) Bronze should not be used in compression when it can be avoided. Steel pro-

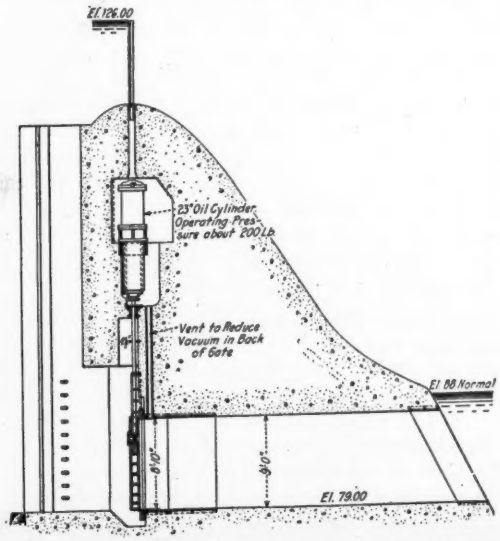


FIG. 1. TYPE OF SUBMERGED SLUICES USED AT VERNON

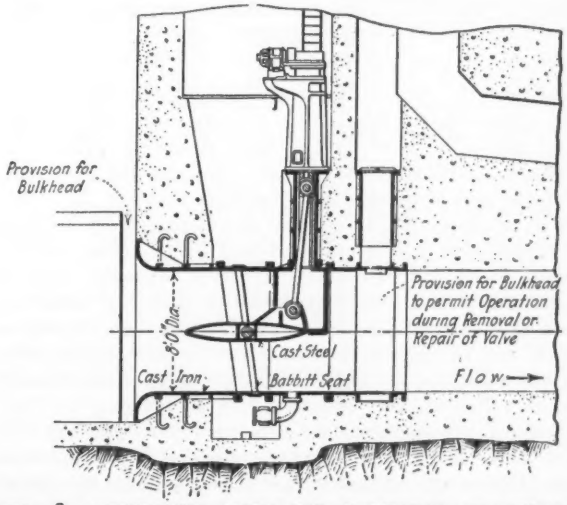


FIG. 2. PROVISIONS MADE FOR BULKHEAD TO PERMIT OPERATION DURING REPAIR OF VALVE

tected by a bronze sleeve is preferable. (4) Metal liners below free discharge gates should be properly anchored back into the concrete, and (5) If a grillage is used before a sluice gate it should be located sufficiently far upstream so that debris caught in it will not trail down stream far enough to obstruct the gate.

Plain sliding sluice gates can be expected, if properly designed, to operate satisfactorily for free discharge service up to heads of 50 to 75 ft. For higher heads the vibration is likely to be excessive and some other type becomes preferable. Several recent installations have made use of a modified design of butterfly valve, known as the disc-arm pivot valve.

One feature of the greatest importance in free-discharge sluice design for any considerable head is the water passage below the gate or valve. It is a common but decidedly questionable practice to flare this passage to increase the discharge by reducing the velocity head lost at exit. Under low heads a considerable increase in discharge ca-

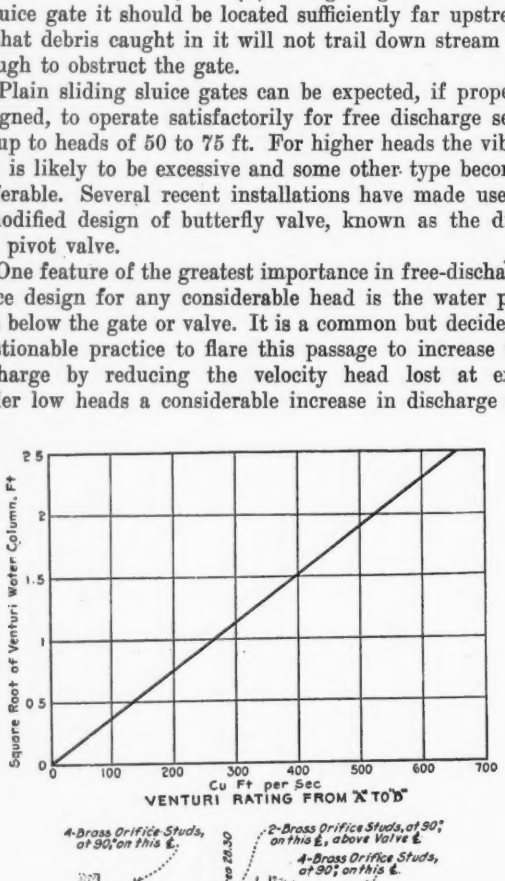


FIG. 3. DIAGRAM AND CALIBRATION OF DAVIS BRIDGE VENTURI INSTALLATION

pacity can be obtained by this expedient, but the percentage effect rapidly falls off as the head goes up. In the majority of cases a trifling flare suffices to reduce the pressure at the valve to absolute zero and the most constricted part of the passage becomes the neck of the bottle. It is never possible to increase the discharge beyond that corresponding to the net head plus 34 ft. acting on this neck. Designs in which the pressures approach absolute zero result in a greatly increased tendency to vibration, and the combination of low pressure and high velocity is ideal for the pitting of metal and erosion of concrete. Vents admitting air to the discharge passages immediately below valves or gates serve to reduce the tendency to vibration and pitting somewhat, but are not a complete cure for the trouble. For the higher heads it is beyond question that the control valve should, whenever possible, be located at the downstream end of the water passage and be allowed to discharge freely into the air.

Clogged racks have probably been responsible for more serious hydro-plant shutdowns than any other one factor. The design of a suitable rack involves the consideration of the size and type of turbine to be protected, the character of trash to be taken care of, the means to be employed for cleaning, allowable head loss, ice conditions, and any special local peculiarities. In general satisfactory results may be expected from velocities in the neighborhood of 1½ ft. per sec. figured on the gross rack area.

Mechanical Rack Cleaning Devices Are Effective

One interesting subject which has been receiving some attention during the last two or three years is the matter of mechanical rack-cleaning devices. It is possible to rake racks satisfactorily by hand to a depth of 15 to 20 ft. but with depths of 30 to 40 ft., such as are being found necessary in large lowhead plants, hand raking is out of the question.

Next in order for consideration are gates used at intakes to water passages, such as canals, tunnels and penstocks, commonly called headgates. These are not ordinarily used for throttling or regulating purposes and the principles involved in their design and selection are not the same as those affecting sluice gates. Headgates are in general protective devices used to shut off the water passages and turbines in case of accident or when drainage is necessary for inspection and repairs. They naturally fall into two distinct classes depending on whether they operate under high or low pressure.

In line with the New England Power policy headgates are designed to close in an emergency under full head with no back pressure, so that it is possible to shut off the flow with the turbine gates open or with the turbine entirely wrecked.

Cylinder hoists have their own inherent advantages and disadvantages. They are extremely rugged and free from complication and are probably less subject to damage by careless or incompetent handling than any other type. A relief valve prevents the development of excessive pressure and nothing is injured if the gate closes against an obstruction, as the pressure simply builds up until the valve discharges.

Handling of heavy as opposed to light gates by hydraulic cylinders introduces difficulties which most of us only come to appreciate through sad experience. The lowering of gates of this type is ordinarily accomplished by bypassing the operating fluid from the bottom to the top of the cylinder, the weight of the gate pulling on the piston developing the pressure which forces the fluid from the bottom to the top. This means that motion is taking place against the pressure, and unless the piston leathers are provided with a separator ring of exactly the correct shape there is a tendency for the lower cup or U-leather to be drawn upward past the upper leather. The result is a severe folding and wedging against the cylinder walls, and the leather soon wears through.

The Broome gate is built with a seat inclined to the guides in such a way that the water pressure on the upstream side has a component in the direction of closure, so that the gate is self-closing if the friction is sufficiently low. In the caterpillar design frictional resistance is largely eliminated by the use of an endless roller chain and a hoist of the tension type only is required, since it is not necessary to force the gate down in closing.

It frequently happens that water is supplied to a hydro station through a single tunnel, conduit, or canal, which

divides into several penstocks to feed individual units. Under these conditions it becomes necessary to provide means for shutting off the water from each unit separately in order to avoid shutting down the entire plant whenever a single unit must be unwatered.

Before passing to other matters it may be worth while to lay somewhat greater emphasis on the importance of reducing leakage in connection with such a plant as Davis Bridge. By actual measurement the leakage through the wheel gates of each unit when first installed and in perfect adjustment was found to be about 9 sec.-ft. This is an exceptionally low value and experience indicates that it may be expected to increase considerably as time goes on. The Davis Bridge units are operated in general on a 9-hr. basis and during the remaining time, at least 5000 hr. per year, they are shut down. Assuming a leakage of 15 sec.-ft. per unit, or 45 sec.-ft. for the plant and an average head of 345 ft., the yearly loss of output would amount to something over 500,000 kw-hr.

Pilot Valves May Be Motor Operated

The turbine-inlet valves used at the lower ends of the Davis Bridge penstocks are of the ordinary butterfly type, furnished by the manufacturer of the turbines. They are provided with bronze seat and snap rings and are controlled by hydraulic cylinders operating on penstock pressure. They have motor-operated pilot valves so that they can, if necessary, be closed or opened from the switchboard.

The valves at the top of the penstocks are of the same size and design as those at the intake, except that a single threaded stem is used instead of the stem and connecting rod adopted for the intake valves. The valves are designed to close under free spouting velocity due to the full head of 160 ft. and are remote-controlled so that they can be closed from the power house in case of accident, the time required to close being about 3½ min.

One of the commonest penstock accidents is collapse due to internal pressures below atmospheric and whenever valves are installed at the upstream end of a pipeline it is necessary to guard carefully against the possibility of a vacuum or partial vacuum occurring if the line is drained with the valves closed. Provision for admitting air may be made either by means of open vents carried above the hydraulic gradient or by the use of air valves designed to open when the pressure inside the pipe drops below atmospheric.

Ice is without doubt the greatest danger. Both vents and air valves must be carefully protected from cold and in most cases artificial heating is required to prevent freezing. Vents should be capable of admitting air at least fast enough to replace water drawn off through the turbine, and this without an undue drop in pressure to draw it in.

Nothing is more important to economy of operation than complete and trustworthy water records and a convenient and reliable method of checking turbine performance. In a high-head plant the use of venturi meters is usually possible but the cost is considerable and the head loss by no means negligible. Several years ago the author's company investigated the feasibility of calibrating an inherited pressure drop at Plant No. 5 and the results were so satisfactory that the practice has been continued in later plants

In order to eliminate the danger of change in calibration due to the formation of tubercles, etc., near the venturi connections, connections are made by the use of brass studs, with faces about 2 in. in diameter, set flush with the inside walls of the waterway.

Reliability of a hydro installation is largely determined before it ever goes into service. It demands suitable equipment, selected with a proper regard to the service required, the use of rugged designs but with careful attention to vital details, and the avoidance of complications.

Government Helps Consumers in Demands for Cleaner Coal

CLEANING TESTS of Central Illinois coal, conducted by the Bureau of Mines, Department of Commerce, in co-operation with the Illinois State Geological Survey and the University of Illinois, indicate that by the use of proper washing methods the screenings and nut-coal sizes of the important No. 6 seam may be made to yield a considerably improved clean coal product, containing no more than 10 to 11 per cent of ash. The development should prove of value to operators in that district as in recent years higher freight rates have created a demand for cleaner coal.

That Illinois coal producers have contributed much to the development of better preparation of bituminous coal for the market, is pointed out by Thomas Fraser, consulting engineer, and H. F. Yancey, associate chemist, authors of Technical Paper 361 of the Bureau of Mines, in which the results of the tests are discussed. More careful sizing and hand picking, and the early introduction of the shaker screen and the screening plant have evidenced this development. Mechanical processes of coal cleaning have aroused much interest, although actual construction of cleaning plants has been rather sporadic. Until recently progress of this kind has been slow because of the lack of interest among the consumers rather than the producers of coal.

So far as Illinois coal is concerned, the demand for cleaner coal comes for the most part from northwestern states. A condition more conductive to profitable washery operation is resulting, and is reviving the interest of Illinois operators in coal-cleaning processes. It is believed that a period of washery building will follow because natural conditions tend to bring about the introduction of better methods of preparation. These conditions include severe competition for markets and the production of a coal in which the impurities concentrate in the small sizes where they can not be removed by hand picking. For this reason much of the Bureau of Mines experimental work on the improvement of the coals of the eastern and interior fields has been done in Illinois.

Copies of Technical Paper 361, "Cleaning Tests of Central Illinois Coal," may be obtained from the Bureau of Mines, Department of Commerce, Washington, D. C.

GREAT CARE should be exercised to prevent leaks in the steam valves to soot blower units as the condensation from such leaks will cause the soot blower units to become warped.

OIL FIRED BOILERS cut out of service should be cooled off slowly, as a quick cooling of the heated furnace brickwork will cause the brick and furnace lining to spawl and crack.

Representative Types of Solid Injection Engines

CHARACTERISTICS OF AMERICAN AND EUROPEAN DESIGNS FEATURED BY HIGH INJECTION PRESSURES AND SPECIAL PUMP CONSTRUCTIONS. BY H. F. BIRNIE

ALL OF the types of engines described in the two preceding articles* have been taken from actual practice, and from successful designs marketed in the United States and Europe.

Figure 1 illustrates the vertical type of the De La Vergne engine; which belongs to the "first group" described in July 15 issue. Being a 4-cycle engine, the shaft actuating the fuel pump must turn at ½ engine speed, which is done by a silent chain transmission. The individual priming levers of the fuel pump are plainly seen on the picture. From the pump the fuel goes to a tee, thence to spray nozzles of the automatic type with lightly loaded springs. These nozzles inject the fuel in a combustion chamber of the design shown in Fig. 2, in the June 15 issue.

In Fig. 2 is shown the horizontal De La Vergne engine which operates on the same principle as the vertical type. The fuel pump and one of the nozzles may readily be seen.

Figure 3 represents one of the engines built by Scott-Still Co. in Scotland. Injection is effected with a heavily loaded differential valve and the fuel pump is driven from the crank shaft (the engine working on the 2-cycle principle) and is located between the two middle cylinders. The Scott-Still engine is in a distinct class differing materially from other engines in that it utilizes the heat contained in the exhaust gases to generate steam, which in turn acts on the lower part of the working cylinders, making the engine double acting. In addition, the installation

*June 15, pp. 642-644; July 15, pp. 745-749.

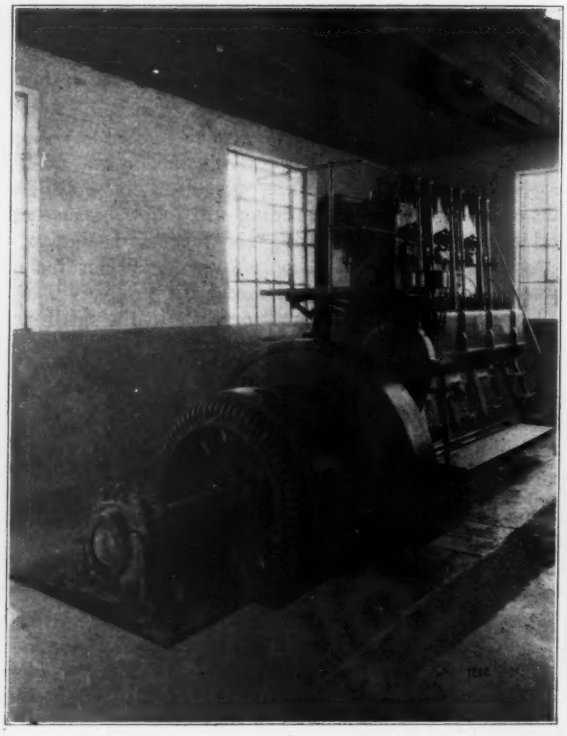


FIG. 1. VERTICAL TYPE OF DE LA VERGNE AIRLESS INJECTION ENGINE

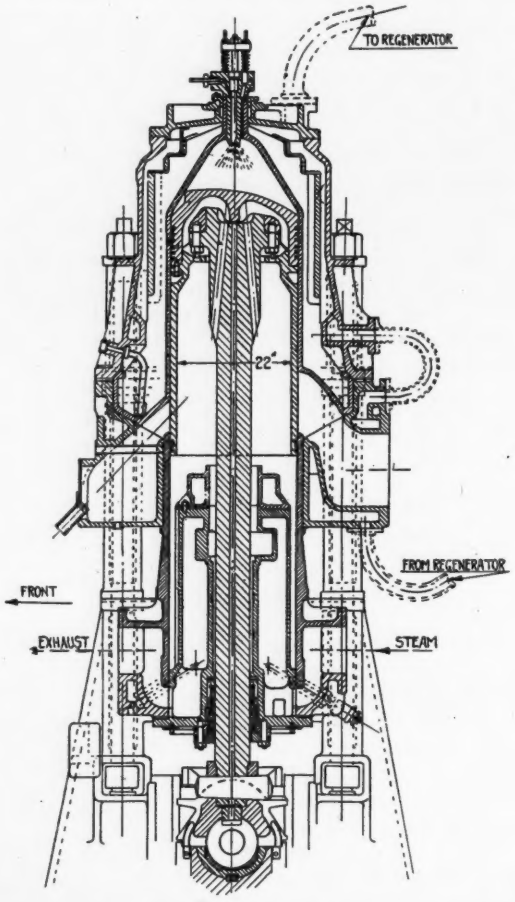


FIG. 3. SCOTT-STILL ENGINE IS DOUBLE-ACTING, USING OIL COMBUSTION ON ONE SIDE OF PISTON AND STEAM ON THE OTHER. BUILT IN SCOTLAND

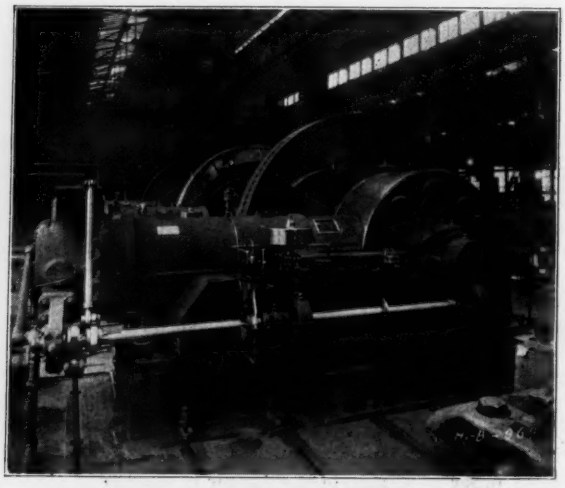


FIG. 2. HORIZONTAL DE LA VERGNE ENGINE

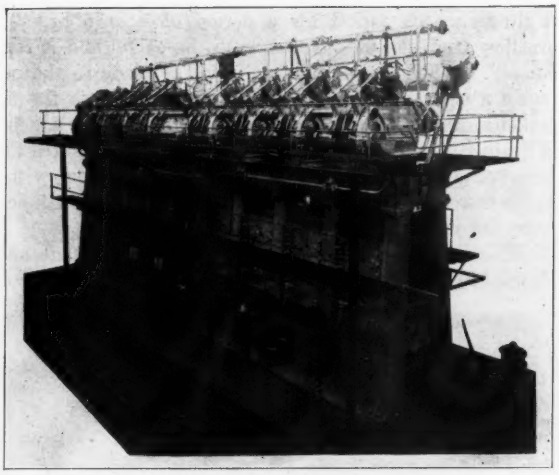


FIG. 4. LATEST TYPE OF ENGINE BUILT IN ENGLAND BY VICKERS. BELONGS TO THE COMMON RAIL SYSTEM

is fitted with an auxiliary boiler, where, when starting, steam is generated with an oil burner. As soon as the engine starts the burner is cut off and the boiler heated by the exhaust gases. The engine is started by means of steam, thereby eliminating all the air receivers and auxiliary air compressors.

In the Scott-Still engine, the fuel pressure, during the injection period, is kept high at all times, varying from 4000 to 7000 lb. per sq. in. The combustion chamber does not, therefore, require any special arrangement for insuring induced turbulence of the air charge.

One of the latest engines built by Vickers in England, belonging to the common rail system, is shown in Fig. 4. It works on the 4-cycle principle and has been adopted for slow-speed marine use as well as for high-speed submarine power plants. The fuel valve rocker arms are situated between those actuating the exhaust and intake valve, which are the most prominent on the picture. A fuel pressure of 4000 lb. is generally maintained though in some cases, this pressure is boosted to 10,000 and 11,000 lb. These pressures, high as they may seem, do not constitute an element of danger due to the small compressibility of the oil. In other words, when a fuel pipe splits open, the oil pressure drops immediately and does not, as in a high pressure air line, burst and hurl fragments of steel in all directions.

The combustion chamber of the Vicker's engine is of conventional design, being limited by a flat-bottom cylinder head and a concave piston top. The end of the spray nozzle has a certain number of holes distributed on its surface so as to give the best burning conditions. The lead of the fuel injection varies inversely with the load of the engine which governs the lift of the fuel valve. In other words, this lead is greatest at the minimum lift of the fuel needle.

Figure 5 shows a Doxford engine built by the Sun-Doxford Co. in Chester, Pa., for the motorship Henry Ford II. This engine works on the 2-cycle opposed pistons principle. The fuel valves generate flat sprays, the fuel jets are opposite each other and offset from the vertical in order to reach all available air in the combustion chamber more easily. As with the Vickers engine there is less injection lead with the heavier and more with lighter loads. How this is obtained is shown in Fig. 6. The

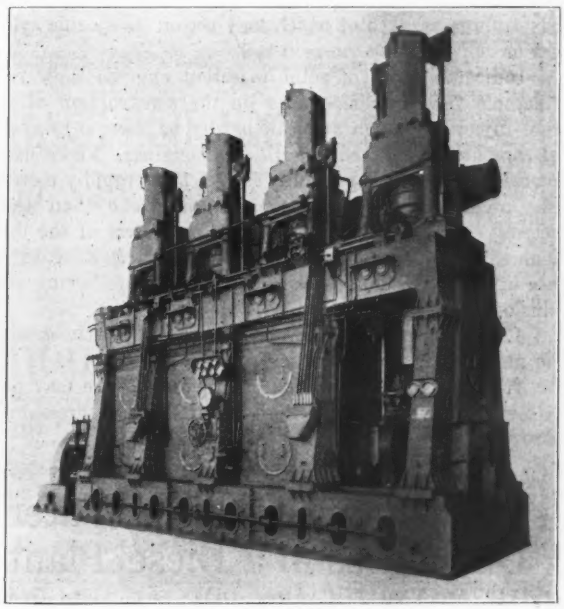


FIG. 5. DOUBLE-ACTING, 2 CYCLE ENGINE BUILT BY THE SUN-DOXFORD CO.

rocker arm E has a fulcrum G and its upper roller is held against the lever DA of the fuel valve by a spring. As the fulcrum G is moved back and forth, the upper roller travels on the curve D, thereby not only changing the time when the fuel needle is lifted, but also the lift itself as the lower roller of E is brought nearer or farther from the fuel cam ground circle F.

Doxford engines use a flat forged steel piston top. The fuel pump, seen at the lower left corner of Fig. 5,

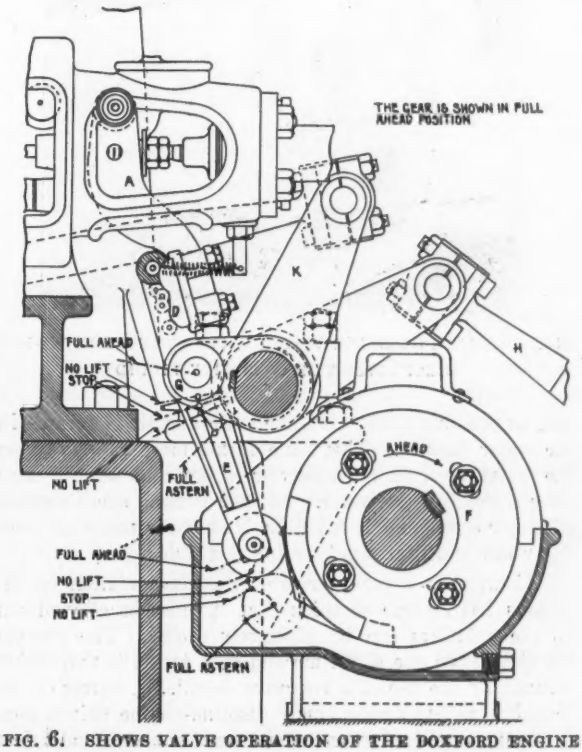


FIG. 6. SHOWS VALVE OPERATION OF THE DOXFORD ENGINE

has 4 plungers, each of which may act on its specific cylinder or deliver into a common rail.

Indicator cards of solid injection engines show considerable variation depending on the construction of the fuel injection system and can hardly be used as a means of comparison between two different engines. Those using increased turbulence generally show a more rapidly increasing pressure during the combustion stroke than those relying on high fuel pressure alone regardless of the thermal efficiency of the cycle. From comparison of actual use of the foregoing types of engines, the following conclusions may be drawn:

1. High spray velocity is required at all times when no induced air turbulence is provided.

2. Only a small fraction of the fuel charge may have a lower spray velocity if high mean effective pressure is desired.

Overcoming Cooling Water Difficulties in a Diesel Plant

CITY WATER FOR Altus, Okla., is obtained from a reservoir in which is stored surface water. The municipal power plant which is equipped with Fulton Diesel engines, uses this city water for cooling the engine cylinders. This water contains scale forming substances

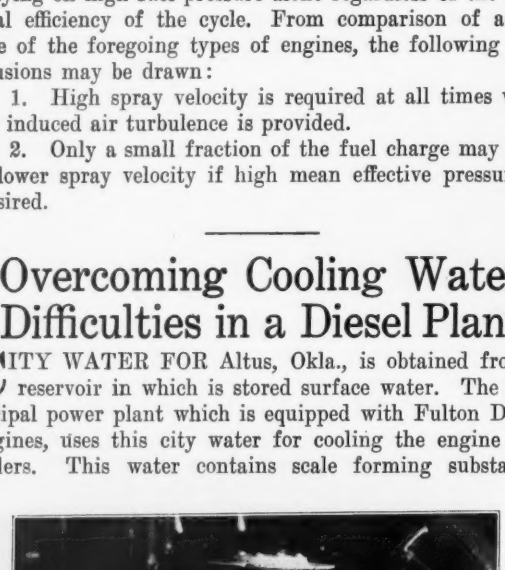


FIG. 1. SMALL GASOLINE MOTOR DRIVES THE PUMP WHICH CIRCULATES THE CORROSIVE LIQUID

and as a result a soft clay-like scale deposit is formed in the water jackets. This scale forms more rapidly when the water level in the reservoir is low and when storms have stirred up the water. At such times a small amount of boiler compound is fed directly into the make up cooling water and thus rapid scaling is avoided.

About once a year, however, the accumulation in the jackets has become so thick that it must be cleaned out so the cylinders can be effectively cooled. The engines are shut down one at a time and each jacket is thoroughly cleaned by the use of a corrosive liquid. A barrel of the liquid is mixed and a small gasoline-engine driven centrifugal pump draws the liquid from the barrel and forces it through each jacket for a period of 4 or 5 hr. The overflow from the jacket returns to the barrel and is recirculated. When the pump connection is made to the next jacket a solution of the compound is poured into the first jacket and allowed to stand about an hour, after which it is drained out. The cylinder head and all plates are then removed and the jacket thoroughly washed out with a water hose. This method thoroughly cleanses all scale from the jacket area.

The fourth and last unit to be installed in that plant was a 500-kw. Diesel which is equipped with water-cooled

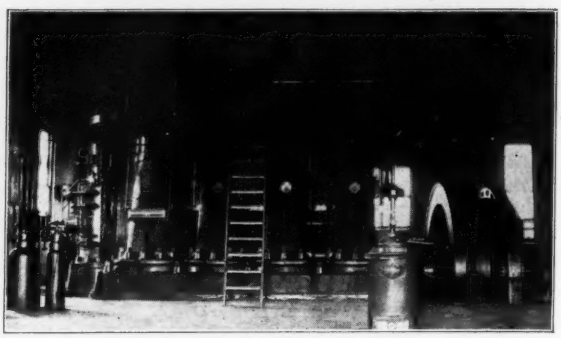


FIG. 2. RATING OF THE FOURTH UNIT IS 500 KW.

pistons. Some oil from this engine works its way into the cooling water and collects in the well, which is part of the circulating system. It is planned to extend the pump suction pipes to the bottom of the well and install an overflow pipe to the sewer so that the oil can be skimmed off.

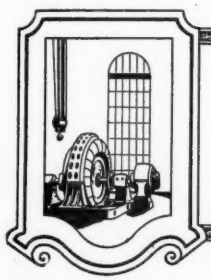
Water Power Data at 1600 Stations

FOR MORE THAN 30 yr. the United States Government, through the Geological Survey, has been systematically gathering information on the water resources of the country and is now making records of stream flow at over 1600 gaging stations. The published records of these investigations now fill 500 volumes and many unpublished reports can be consulted in manuscript at the offices of the Geological Survey at Washington or at its district offices throughout the country.

Surveys are made along rivers at the rate of 500 to 1000 mi. annually and their results are published in the form of river profiles. Wherever feasible sites for dams and reservoirs are found, detailed surveys are made for publication on maps of large scale. The general topographic maps made by the Geological Survey are also used in water-power studies.

After the fundamental data on water supply, river fall, and storage are collected, they are assembled and analyzed by river basins, the best possible method of development is outlined, estimates of the potential power available are made, and the public lands are classified with reference to their value as power sites.

PIPE EXTENSIONS should never be used on wrenches for tightening blowoff valves or blowoff cocks. If the boiler blowoff valve or cock does not seat properly there is in all probability a piece of boiler scale or other foreign matter on the seat which should be flushed off by cracking the valve. Forcing the valve results in scoring the seat.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

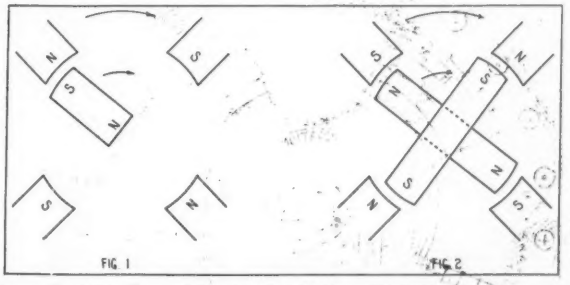
Principles of Synchronous Motor Action

EXPLAINING THE ACTION OF THE SYNCHRONOUS MOTOR IN PRODUCING A LEADING CURRENT. BY CHARLES G. GREEN*

SYNCHRONOUS motors are made in two general types, with stationary d.c. fields and rotating a.c. armature, with slip rings, in the smaller sizes; and with rotating d.c. fields and stationary a.c. stator in the larger sizes. The latter type being the more common will be the ones referred to in the remainder of this article. They require a source of direct current for field excitation and a source of alternating current for line load current. The direct current can be obtained from a direct current line, if available, or from an exciter generator on the shaft of the synchronous motor or belted to it, the same as would be used for an alternator.

Synchronous motors are made to operate on either single or polyphase systems, and are called synchronous because they always run in synchronism or in step with the alternator driving them. In other words, the rotating part will complete one revolution in the same time it takes a magnetic pole of the stator or a.c. winding to travel one complete revolution. It must be understood for the synchronous motor, the same as with the induction motor, that it has a rotating magnetic flux, the speed of which may be determined by the same method as used with the induction motor. Any one magnetic pole makes one complete revolution in the field structure in as many cycles as there are pairs of poles. If f represents frequency in cycles per second, and n the number of pairs of poles, the number of revolutions of the magnetic poles per second is f/n, and the revolutions per minute or synchronous speed is $60 \times f/n$. When the speed of a motor is in accordance with this formula, or when the speed of the rotating element in revolutions per minute is the same as the speed of the rotating magnetic field, the motor speed is said to be synchronous with that of the alternator supplying the power to run the motor.

Synchronous motors are easily understood if the rotating field, as given in the July 1st issue† of this magazine, for the induction motor is understood and also the principles of simple d.c. generators. If we take the stator of an induction motor, which is wound for a rotating field, and then place a small bar magnet in it, pivoted so it is free to rotate, as in Fig. 1, and connect the field or the stator winding so it has a rotating magnetic field as shown by the large arrow the south pole of this magnet will be drawn around in the same direction as the field. Now put another magnet in and fasten it to the same pivot at the center, and then add another, and another, until we have the same number of poles on the rotor as we have on the stator, as in Fig. 2, letting the north pole of a permanent magnet be under or near a south pole of the rotating magnetic field, and a south pole of a permanent magnet, or rotor, under a north pole of the field, or they may lag back a bit due to having a load connected to them, or they



FIGS. 1 AND 2. SIMPLE DIAGRAMS SHOWING EFFECT OF ROTATING FIELD UPON PERMANENT MAGNET ROTORS

may be weak and lag back a bit until they get near enough to the pole behind them, which if you notice will be of the same polarity, and will begin to repel them, which will also help to keep them up to speed. With the four poles on the rotor it can readily be seen that they will have much more power than in Fig. 1 where there was just one. Now if instead of the small permanent magnets for the rotor, we put electro-magnets excited by direct current so as to be of the same polarity at all times, the same as a permanent magnet, it can be seen that we can make them weak or strong at will, by simply inserting a variable resistance in series with the supply circuit and send the current for the fields to the coils by the use of collector rings as shown in Fig. 3. Now suppose the alternating current be sent through the stator windings to produce the rotating magnetic field, and at some one instant let the current in the different wires be as indicated in Fig. 3, a dot enclosed in a circle indicating a current toward the observer, and a cross, a current away from the observer.

If we have a three-phase stator, we must have all three phases combining to produce each pole and it can be seen in Fig. 3 there are two conductors per pole, per phase, then we have three phases or $3 \times 2 = 6$ conductors per pole. Assuming now that phase A is the next to reverse we can see that the two conductors shown for the start of A "(SA)" or one side of the coil and also the two conductors marked F.A. or the finish of A phase for the other side of the coil will have reversed current in them. Then by checking the new position of the magnetic poles of the stator, it will be found that they have shifted to the right on top and as A phase must feed coils in all

*Instructor in motor department, Coyne Electrical School.
†Principles of Induction Motor Action, page 701.

poles then the other poles on the bottom will be shifted over in the same direction of rotation or clockwise. By applying magnetic rules it is evident that the poles of the rotor will be drawn around in the same direction as the rotating magnetic field, as in Fig. 3. Now if these rotor poles, or as we will call them, the d.c. field poles, are weak, they will not have enough attraction for the revolving field, and will drop back until the magnetic pole behind it or one of its same polarity begins to repel it. It will then rotate in between these two poles in synchronism.

If, however, we were to strengthen the d.c. field it would be attracted more strongly, also repelled more strongly and it would take up a new position a little in advance of its present location with regard to the rotating magnetic field of the a.c. winding and continue to rotate in synchronism. We may also excite or strengthen the d.c. field enough so that it would actually be almost directly under

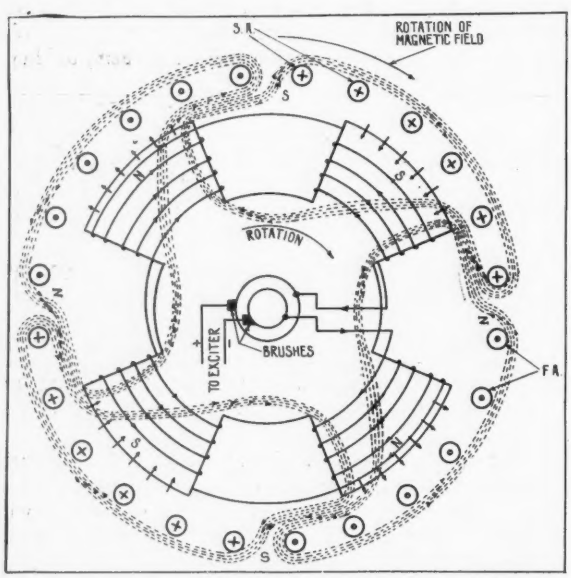


FIG. 3. DIAGRAM OF SYNCHRONOUS MOTOR SHOWING ACTION OF FLUX IN PRODUCING ROTATION

the definite polarity as shown in Fig. 4C. Now if a load be thrown on the motor, there is no longer enough attraction to keep it up to its new position and again it drops back, this time due to a load and not from a weak field, until it is again being repelled by the same polarity from behind and carries the added load. If the load becomes too heavy the rotor will lag more and more until it loses its attraction for the revolving magnetic poles in advance of it; at the same time, due to the lag of the rotor, the like polarity of the stator or rotating magnetic field has a neutralizing effect upon the d.c. field and weakens it. Under these conditions the rotor drops out of step and by the time the next opposite polarity comes around it cannot speed up again enough to carry the load, with the result that in a few moments the motor comes to a sudden stop.

If at the time the heavy load was put on, the d.c. field had been increased, then it might have carried the load and kept in synchronism. The conductors of the stator being stationary, and just the rotating magnetic field causing the d.c. field or rotor to be drawn around in the direction of the rotating magnetic field of the stator, it is evident that the flux of the d.c. field will be sweeping across the stationary conductors at a high speed. This flux cutting across these conductors will generate a voltage in them exactly as if the d.c. field was stationary and the conductors of the stator were rotated in the opposite direction. Now by the use of various rules such as Fleming's right hand rule for generators, as given in an article on Induction Motors in the July 1st issue, the direction of the induced voltage in the stator winding will be found to be exactly opposite the current in this winding, as shown in Fig. 4A, where the d.c. magnets are assumed to be weak. With the field weak it will be lagging or about midway between the definite poles produced by the a.c. winding, and will also be generating a very low voltage in the a.c. winding, in this way allowing a large amount of current to flow in the windings by virtue of the impressed voltage. This increases the inductive reactance and the current as a consequence lags behind the line voltage. The alternating flux or any flux as it builds up around a wire induces a voltage in that wire in a direction opposite to the current producing the flux. The current, therefore, lags behind the impressed voltage and is out of phase with it. When the impressed voltage decreases to zero and reverses, the current and its flux also decreases. Thus the flux cuts the conductor in the opposite direction and instead of generating a voltage which opposes the current, now generates a voltage which tends to aid it. This causes the current to lag still more behind the line voltage.

We see then that if we increase the current we increase the flux and the more flux we have reversing, the more voltage will be generated to keep the current lagging behind the voltage. This effect is commonly known as "inductive reactance." The power factor of any alternating current circuit is equal to the cosine of the angle of lag of the current behind the voltage, or angle of lead in regard to the voltage, if such is the case. Where it is leading instead of lagging we say it has "condensive or condenser reactance" or in other words if a large condenser be connected across the mains of an a.c. line as in Fig. 5, and the current is flowing due to the pressure or voltage, there will be a positive charge accumulated or forced into the upper half of the condenser, and the lower half will be negative. At this instant while a strong positive charge is in the upper half, or in other words, a high pressure is there waiting for a chance to get out, if we reverse the voltage of the line, this high pressure stored up in the condenser will immediately overcome the effect of the "inductive reactance" trying to keep the current from reversing, and will give current a kick so that it will reverse at the same time as the voltage, and if the condenser is made large enough it will even reverse the current before the voltage and produce leading current. When the condenser is discharged for that half cycle and then charged in the opposite direction, this opposite charge gives rise to a pressure performing the same function as before for the other half cycle.

Effect of Increasing Excitation

Now if we excite the d.c. fields of the synchronous motor more strongly we shall generate a higher voltage in the stator, which will be in opposition to the impressed voltage and will allow it to force less current through the stationary coils. The inductance reactance will be less, in other words, and the current will be able to keep more nearly in step with the voltage. In this way the power factor will be increased or as the angle of the lag of current behind the voltage becomes less and less as we

strengthen the field, the cosine of this angle will also come nearer and nearer to unity or 100 per cent power factor, and at the same time the d.c. magnets will be taking up a new position as in Fig. 4B.

Now it might be thought that the decreasing of the current in the stator by the E.M.F. induced by the d.c. field would weaken the rotating magnetic field of the stator, but such is not so because, as stated before, the current being decreased also decreases the reactance, and allows what current is left to keep nearer in step or in phase with the voltage. It can be seen then that the current which has actually been done away with was out of

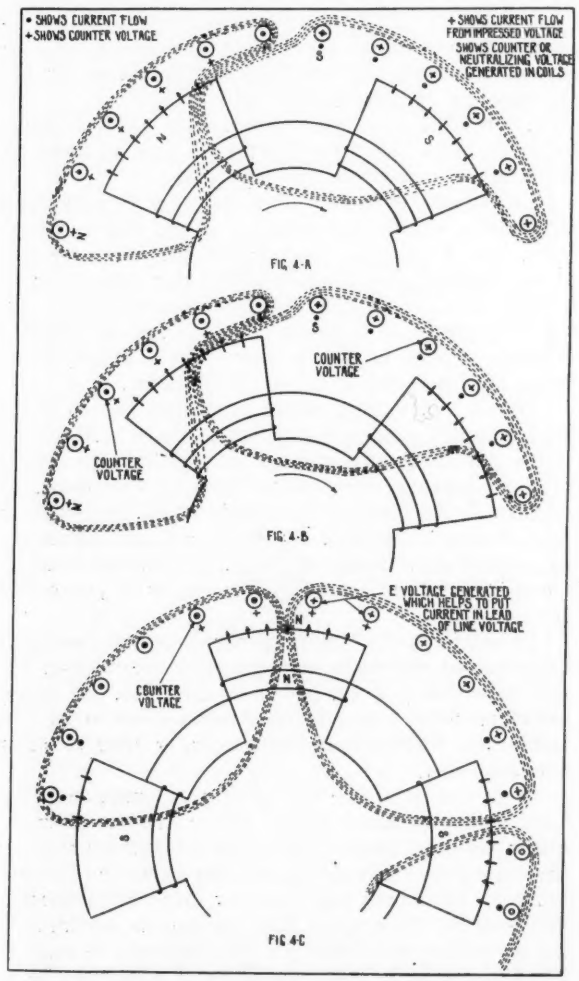

• SHOWS CURRENT FLOW
+ SHOWS COUNTER VOLTAGE
+ SHOWS CURRENT FLOW FROM IMPRESSED VOLTAGE
SHOWS COUNTER OR NEUTRALIZING VOLTAGE GENERATED IN COILS
FIG. 4-A
COUNTER VOLTAGE
COUNTER VOLTAGE
FIG. 4-B
E VOLTAGE GENERATED WHICH HELPS TO PUT CURRENT IN LEAD OF LINE VOLTAGE
COUNTER VOLTAGE
FIG 4-C

FIG. 4. DIAGRAM ILLUSTRATING EFFECT OF VARYING FIELD STRENGTH IN SYNCHRONOUS MOTORS

phase with the voltage, and when we have current out of phase with the voltage it is ineffective current. Furthermore, as it takes current and voltage to produce power, we find that the neutralized current was what is commonly called wattless current. Now if we excite these fields still more and continue to improve the power factor by doing away with wattless current, we find that the d.c. field poles will become so strong as to draw up in a position as in Fig. 4C, when they will not only be generating or inducing in the stator winding a voltage which will do away with the lagging of current but in part of the coils as shown by the arrow E, will be generating a voltage that will actually advance the current flow. This produces a leading current that will feed back on the line a little in advance of the line voltage and neutralize the effect of inductive reactance in some other part of the system. It must be understood, however, that if we have more leading current than is necessary to neutralize the lagging effect, in the rest of the system, we shall have the excess of current leading the voltage, and as it is out of phase with the voltage it is wattless current, leading and just as detrimental to the alternator and apparatus in general as wattless current lagging behind the voltage. We find by the foregoing that by strengthening the d.c. field of a synchronous motor we can use it to run a mechanical load and also to correct power factor.

If the field of a synchronous motor of proper size for the system to which it is connected and which is operating on a line with a lagging current is gradually increased while the load remains constant, the lag of line current will be decreased to a minimum value, while further excitation of the field will produce a leading current. As the field is increased in strength, we find a time where the condenser effect is just sufficient to neutralize any current

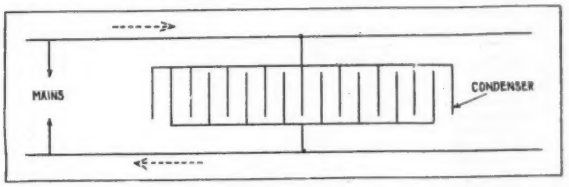


FIG. 5. A CONDENSER PLACED ACROSS AN ELECTRIC CIRCUIT PRODUCES A LEADING CURRENT

lag of the system and at this point our power factor is best. If we still further increase the field we begin to lower the power factor in the opposite direction.

Starting Synchronous Motors

The motor speed cannot change for it must rotate in step with the alternator driving it, nor does the line voltage change. The voltage generated by the motor must change with a change of field excitation. If we wish to start a synchronous motor and let it come up to speed by its own power, it will be found possible to do so by putting a squirrel cage winding imbedded in the pole faces and strapped together between poles so as to produce in effect, an induction motor with a squirrel cage winding. The motor can now be thrown directly across the line as an induction motor and let come up to speed before exciting the field, or it can be brought up on low voltage, till it is almost up to synchronous speed and then by exciting the field and throwing the switch over to the high voltage it will pull into step and run synchronous. Synchronous motors without this provision have extremely poor starting torque. Several other methods of starting are in use, but the most modern is the one just explained. If a synchronous motor is not available and we have an extra alternator it can be used for the purpose of power factor correction and in some cases to a great advantage. If it be brought up to speed and synchronized with the other machines, then by over exciting the fields and shutting off the steam, or by allowing a small amount to pass through the throttle if it is a very large alternator the power factor of the system to which it is connected can be controlled. If a steam turbine driven alternator is used

it will be necessary to allow about the same amount of steam to pass through the turbine as would be required to run it idle at full speed. Without this steam the turbine buckets or vanes might overheat due to excessive windage. A machine designed purposely for a synchronous condenser usually has a very small air gap or clearance between stator and rotor in order that maximum over-excitation may be obtained.

An easy way to understand the synchronous motor as a condenser or as a machine to improve the power factor and assist the system is just to consider that it generates current within parts of its own windings that is actually leading the line voltage supplied by the alternator, and, if the machine is of sufficient size, it generates enough of this leading current to neutralize the lagging current caused by the inductive equipment.

Progress in Rural Electric Service*

DIFFICULT TO ADAPT DRIVING SPEEDS OF FARM EQUIPMENT TO STANDARD MOTOR SPEEDS

DURING THE past year the United States Department of Agriculture has made a very complete survey of the primary power now being used on the farms of the United States. C. D. Kinsman, service agricultural

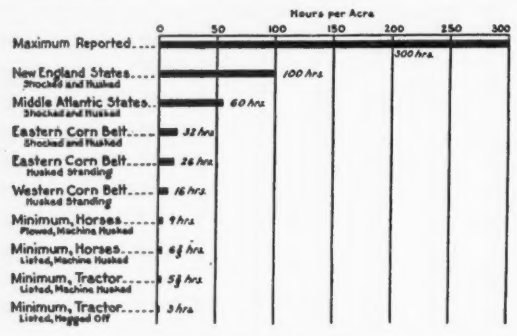


FIG. 1. HOURS OF MAN LABOR REQUIRED FOR CORN PRODUCTION

engineer, United States Department of Agriculture, presented a summary of this survey before the 18th annual convention of the American Society of Agricultural Engineers, held at Lincoln, Neb. This survey shows that:

a. The total primary power used in United States Agriculture is approximately 50,000,000 hp.

b. The total horsepower-hours developed annually in this industry is approximately 16,000,000.

c. The cost of power on farms in the United States at present values is about $3,000,000,000.

d. By the use of this power, together with modern labor-saving equipment, the American farmer is enabled to increase his production per man by at least three times over what was possible with other methods 75 yr. ago.

e. An extremely close relationship exists between the amount of power and machinery used per worker and the volume of production.

f. A large number of workers have been released from agriculture by the employment of power and machinery on the farms.

Figures 1, 2 and 3 are valuable as basic information in the study of rural electrification. The comparison of agriculture with other industries is surprising in the nature of its disclosures. Figure 1 points out most emphatically that:

1. Agriculture must employ more power, or

2. It must utilize what power it now employs, a greater number of hours per year, i.e., improve its load factor.

3. The investment for primary horsepower could be reduced below that of manufacturing industries by the economic use of more power, and

4. In addition of more power, some could profitably be employed in the "manufacture of farm products on the farm" from their own raw materials.

The horsepower-hours utilized per worker on the farm is, of course, affected by seasons, locations, nature of farm crops, etc. There is no question but that in a large part of the farming industry in this country some form of automatic machinery which could be made to operate during the night or at times when the average farm worker is unable to perform such work would tend greatly to increase the hour's use of power on the farms.

Figure 2 shows that only a very small portion of the total estimated primary horsepower available on the farms of the United States is supplied electrically at the present time. By including all individual farm lighting plants, approximately 2,000,000 of the 50,000,000 hp. is electric, or four per cent of the total. By replacing steam engines and gas engines now doing belt work, this amount could be increased to 12 millions of horsepower, or to 24 per cent of the total.

From Fig. 3, if all of the power operations that could be performed electrically at the present time without further development work, had been electrified, the energy consumption for a year in farm power alone would have been nearly 5 billion horsepower-hours, or nearly 4 billion kilowatt-hours.

If to this is added the lighting consumption in the farm homes estimated at two billion kilowatt-hours annually, we get a total of six billion kilowatt-hours as the amount required for lighting the farm homes and for operating the belt-driven machines now used on the farms of this country. This figure does not include anything for the 30 million man-hours per year necessary to carry on our agricultural industry and some of which can be replaced by electrical machinery. Neither has any figure been included for electric cooking, refrigeration, water heating in the dairy, electric lighting in the hen house and at the feed lot and many other special applications, all of which will be used in varying amounts when electricity is made available to the farms of this country.

DEVELOPMENT OF FARM EQUIPMENT SUITABLE FOR ELECTRIC DRIVE

Two definite steps have been taken during the past year in the development of farm equipment suitable for the electric drive. These steps may be designated as follows:

1. Experimental lines operating under the auspices of state committees have developed so that we know what many of these equipment problems are.

*Abstract of a report by the Rural Electric Service Committee of the National Electric Light Association.

2. These problems have been brought directly to the attention of the manufacturers of motors and the manufacturers of farm equipment. There is reason to believe that both these industries recognize that there is work for them to do and will proceed accordingly.

Investigation has shown that in the household, electrically-driven labor-saving devices are even more of a necessity in the farm house than in the city home. There are many facts to support this contention; to begin with,

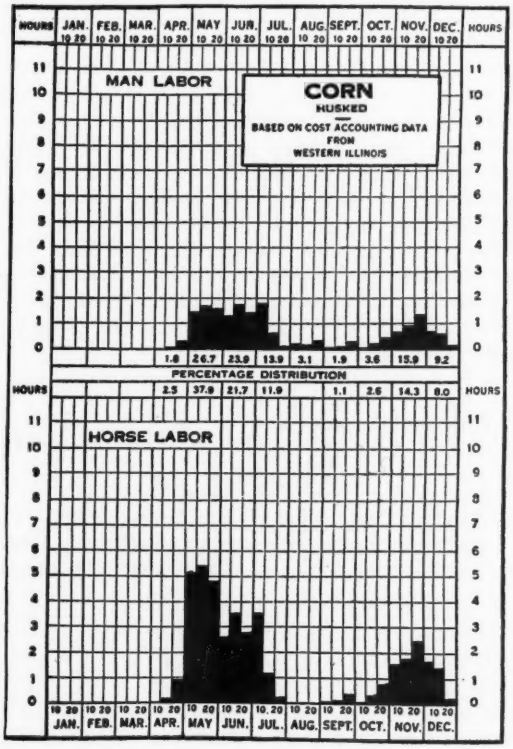

MAN LABOR
CORN
HUSKED
BASED ON COST ACCOUNTING DATA FROM WESTERN ILLINOIS
1.8 26.7 23.9 13.9 3.1 1.9 3.6 15.9 9.2
PERCENTAGE DISTRIBUTION
2.5 37.9 21.7 11.9 1.1 2.6 14.3 8.0
HORSE LABOR
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEPT. OCT. NOV. DEC.

FIG. 2. DISTRIBUTION OF MAN LABOR AND HORSE LABOR FOR 9 FARMS PRODUCING A TOTAL OF 426 ACRES OF CORN. MOST OF THE CORN ON THESE FARMS WAS HUSKED FROM STANDING STALKS

there probably are more people in the average farm home, due either to larger families or to the presence of hired hands, or both.

Household Equipment

The commercial laundry is available to the city housewife, and used to a greater or less extent depending upon circumstances. In the country, laundry work is generally done in the home.

Likewise, the city bakery is usually convenient to the city housewife, while the people in the country must depend much more on home baking.

Conditions of operation in the country also will be found to vary from conditions in the city. The city housewife can order a washing machine by telephone, and have the machine installed in the laundry. It can't be done that way on the farm. In the first place, there frequently is no laundry. A suitable place must be found for the washing machine. In the second place, in the majority of cases, there is no running water. A pump motor must be installed and a pipe line extended to the house. Next comes the problem of heating that water.

In the country home the electric range also presents a problem far different from the city. In many cases the wood or coal range is relied on to cook the family meals, to heat the kitchen in winter and to keep a large supply of water hot at all times, all of which presents problems for the electric range.

Also a problem relating to the size of oven is developing. The farm woman bakes bread once or twice a week, and when she does, wants to bake a lot of it. The oven

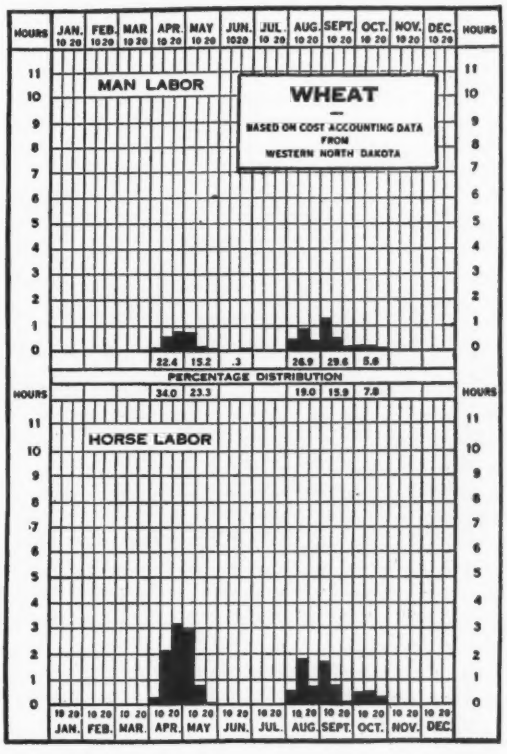

MAN LABOR
WHEAT
BASED ON COST ACCOUNTING DATA FROM WESTERN NORTH DAKOTA
22.4 15.2 .3 26.9 29.6 5.6
PERCENTAGE DISTRIBUTION
34.0 23.3 19.0 15.9 7.8
HORSE LABOR
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEPT. OCT. NOV. DEC.

FIG. 3. DISTRIBUTION OF MAN LABOR AND HORSE LABOR PER ACRE FOR 16 FARMS, REPRESENTING THE PRODUCTION OF 960 ACRES OF WHEAT. ON 11 OF THESE FARMS THE THRESHER FURNISHED A PART OR ALL OF THE CREW FOR THRESHING

big enough for city service may not be adequate for the farm house.

Farm Equipment

On many of the investigation projects today, the lack of farm equipment designed to use the maximum possibilities of the electric drive, has become the limiting factor in the development of this work. There are some notable exceptions to this, such as the cream separator, milking machine, and water pumps, but on the whole, we are confronted with equipment which has been designed for prime movers having far different characteristics than the electric motor.

As a result of this experience, the farm equipment problems may be divided into two general classes: (1) What are the most practical ways of adapting electric drive to present farm equipment? (2) What changes are desirable in order that the farmer may be able to secure maximum results from the electric drive?

There is a large amount of equipment on farms now, and more is being sold all the time, which the farmer will

not want to discard for a number of years. It is felt desirable that some means be developed whereby this equipment can be operated by electric drive. As most of this equipment has been designed and built for prime movers with from 300 to 650 r.p.m., it would appear that at least during this development period, it is desirable to provide for some speed changing device which would give the variety necessary to meet the situation.

In only a few cases has a thoroughgoing attempt been made to adapt the electric drive to farm machinery or farm machinery to the electric drive. The efficient, moderately priced electric motor is a high speed machine, while most farm implements are built to run at low and variable speeds. When the farmer attempts to apply electric power to farm implements, generally he finds it a very difficult job, and one which he usually abandons before accomplishing anything.

Following are the problems which the experimental lines have developed:

1. Drive pulleys on present farm machines are not made to run at the same belt speeds for different machines and therefore any motor with a given size pulley will not run the different machines at the proper speeds.

2. Pulleys of sufficient size to give low speeds to farm equipment cannot be used because in some instances they would have to be as large as eight feet in diameter which naturally would preclude their attachment to farm implements.

3. The use of gears at the motor to secure low speeds introduces many new problems.

4. In belt drive, the use of any speed reduction devices at the motor would require the use of slow speed belts to the farm machine and such belts would need to be wide, driven under high tension, would have short life and are inefficient.

5. Certain types of farm implements such as the threshing machine should be run at two or three different speeds according to the type of grain that it is handling.

Countershafts, speed jacks, and back-geared motors are being used on the various experimental lines and are today driving various types of farm implements but are crude and not satisfactory, for the reasons above stated. In addition thereto, different size pulleys are being used on the motors, but experience emphasizes that frequent changing of the pulleys will soon render the shaft and pulley unusable.

If standard belt speeds can be adopted and farm machinery equipped to be driven with belts at these speeds, then the application of electricity to agriculture will be advanced materially and rapidly.

On one of the experimental lines the portable general use motor is being connected to the farm equipment through an automobile transmission and a short shaft containing two universal joints. This machine has not been tried out sufficiently to justify itself, but this method of applying power deserves and is receiving careful study and attention.

The foregoing recital of difficulties encountered in applying this new motive power to agriculture does not mean that the project directors in charge of the various experimental lines have been content to wait for the way to be made easier for them. On the contrary, their initiative and inventive ability has enabled them to apply electric power even under the adverse existing conditions. The result is that while many applications are crude and primitive, nevertheless electricity is today driving a countless number of different types of equipment on the experimental lines.

Farm households are equipped with ranges, electric refrigerating machines, washing machines, irons, vacuum cleaners, dishwashers, water heaters, motors for sewing machines, fans, curling irons, toasters and percolators.

About the farmstead, electricity is sawing the wood, grinding the feed, cutting the silage, running numerous shop tools, threshing the grain, hoisting the hay, mixing concrete, drying hay and grains, elevating grain, irrigating waste lands, and performing countless other tasks.

Some of these applications, however, are crude and some of them have been difficult of accomplishment. The real point is that the farmer never is going to become a considerable power consumer until it is made possible for him to obtain electric equipment for these tasks as readily as he can obtain electric equipment for his cream-separator. When that day is reached, the farmer will be found ready to apply electricity to agriculture.

No further progress has been made during the past year regarding the application of electricity to field work. In a number of places individuals are working on this problem, but it must still be looked upon as an experimental adventure.

The Hunt Self-Paralleling Alternator

Alternating Current Generator Does Not Require to Be Synchronized Before Connecting in Parallel with Other Machines

IT IS A COMMONLY known fact that an ordinary polyphase induction motor, if driven at a speed exceeding that of synchronism, will act as a generator, returning energy to the line from which it would be supplied when running as a motor. An interesting property of the induction generator is that it requires no synchronizing, the frequency of the output being always equal to that of the line, quite independently of the speed of rotation so long as this exceeds the synchronous speed. The drawback of such machines, however, is that they are not self exciting, the excitation current having to be supplied from the line. The excitation current, moreover, is comparatively large, amounting to something of the order of 30 per cent of the full load output of the machine as a generator. An induction generator of the ordinary type can, therefore, be used only in parallel with synchronous generators which supply the magnetizing current and for this reason but few practical applications have been found for machines of the former type.

Recently, however, a new type of induction generator, possessing the advantages of that type of machine without the inherent drawbacks, has been developed in England, by L. J. Hunt. This generator, which is described in a recent issue of Engineering of London, of which article this is an abstract, is in effect a combination of an induction and synchronous generator in a single machine. The result is an alternator which does not require to be synchronized before connecting in parallel with other machines, and will, therefore, run satisfactorily in parallel under conditions which, under parallel running of ordinary alternators, would be quite impossible.

Although in the actual machine the synchronous and asynchronous portions are combined in a single stator and

rotor, the principle on which it operates can best be understood by considering the two parts separately, as drawn diagrammatically in Fig. 1. As there shown, the excitation current is supplied by a continuous-current generator to an 8-pole stator winding generating current at a frequency of 16 cycles per second in a rotor driven at 250 r.p.m. This current, supplied to a 16-pole rotor winding of a separate machine, would produce a field rotating at 125 r.p.m., even if the rotor itself were stationary. If, however, the rotors of the two machines are mechanically coupled so that both rotate at the same speed, i.e., 250 r.p.m., a field rotating in space at 375 r.p.m. can be produced by the rotor of the second machine. Under these conditions, if the stator of the latter is provided with a 16-pole winding, alternating currents with a frequency of 50 cycles per second will be generated in that winding, and these currents can be tapped off to supply the line.

In practice, instead of employing separate mechanically-coupled machines, the generator has a single stator core provided with windings giving the resultant of the 16-pole and 8-pole fields. The construction adopted is similar to that of an induction motor, the stator and rotor cores being built up of laminations provided with slots for the windings, the slots of the stator being open and those of the rotor almost closed. In the rotor slots is a simple short-circuited winding producing the same

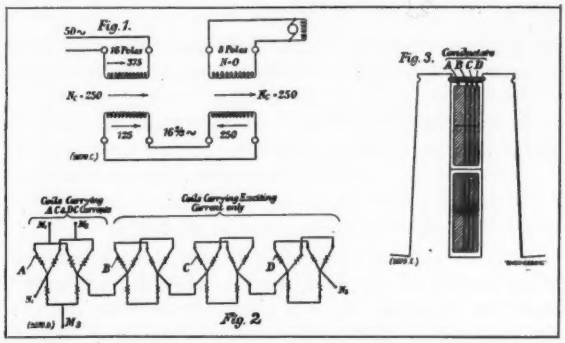


FIG. 1. DIAGRAM SHOWING PRINCIPLE OF THE HUNT ALTERNATOR

FIG. 2. KEY SHOWING POSITIONS OF THE FOUR CONDUCTORS, A, B, C, D

FIG. 3. METHOD OF ARRANGING CONDUCTORS IN SLOTS

effect as two independent 16-pole and 8-pole windings. The rotor of the particular machine to which we wish now to refer has 192 slots, in 96 of which there are two bars each, while in the remainder only one bar is required. In the stator there are 144 slots, in which are placed the windings shown diagrammatically in Fig. 2. In this figure, N_1 and N_2 indicate the connections through which the continuous exciting current is supplied, and M_1, M_2, and M_3 are the points at which the alternating current (three-phase) is tapped off. It will be seen that the latter is supplied by two sections of the winding connected to form two parallel stars. The exciting current flows through this winding, entering at the neutral point of one star and leaving from the neutral of the other. In each pair of parallel branches of the winding, the exciting current flows in the same direction as the alternating current in one star and in the opposite direction in the other star, the effect of the exciting current being to produce only eight poles, while the alternating current produces 16. The remainder of the winding carries the exciting current only, all the units of the winding being connected in series with the exciter.

By arranging the windings in four similar units and placing similarly-situated wires of each unit in the same slot, as indicated in Figs. 2 and 3, the insulation required can be reduced to a minimum, since there is no difference of potential between them—a feature which materially simplifies the construction. Moreover, by arranging the units in this way, the necessary paths are provided for the flow of the induced current, upon which successful parallel operation depends. The stator winding is so arranged that when the rotor speed is not synchronous, the currents induced in it produce mainly a magnetizing effect, the restoring torque being developed by the rotor current. It

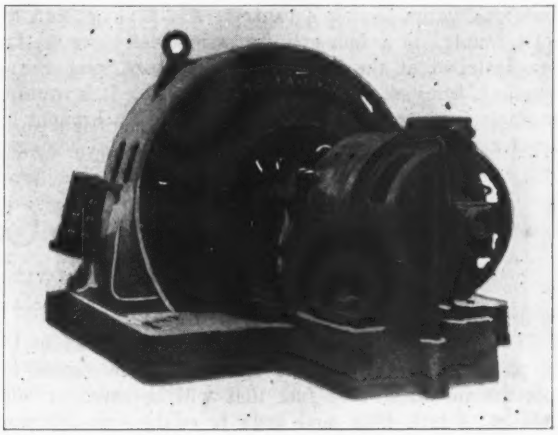


FIG. 4. THE HUNT SELF-PARALLELING ALTERNATOR

has been found, we understand, that if a stator winding is used which permits the induced currents to flow mainly across the center of the eight-pole winding, so as to provide a large restoring torque, the self-paralleling property of the machine is lost.

Two alternators of the type referred to have recently been put down to supply power to the Leckhampton Quarries, near Cheltenham, the machines having been constructed by Messrs. Sandycroft, Limited, of Sandycroft, near Chester, to the specification of H. D. Wilkinson, M. I. E. E., M. I. Mech. E., consulting engineer, of 56 Victoria street, S. W. 1. Each of the machines, one of which is illustrated with its exciter in Fig. 4, has a full-load capacity of 160 kw. at a power factor of 0.8, and generates three-phase, 50-cycle current at a pressure of 440 volts. The machines are each directly coupled to a four-cylinder horizontal gas engine, constructed by the Premier Gas Engine Company, Limited, Sandiacre, Nottingham, and running at 250 r.p.m.

Some particularly interesting tests were carried on at this installation to illustrate the remarkable self-paralleling characteristics of the Hunt alternators. With the two sets at first running normally, one cylinder, and then two cylinders, of one of the sets were cut out, the machines remaining in step perfectly with one engine firing on four cylinders and the other on two. Continuing this test, the sets were run with three cylinders of each engine firing, and one cylinder of each engine was then cut out in succession, so that both sets were eventually running quite satisfactorily with only two cylinders firing. This test could not be carried farther as the engines could not be

operated with one cylinder only, but they serve to indicate that, by employing self-paralleling alternators, the necessity for applying a very uniform driving torque is avoided, and the cost of constructing internal-combustion engines can therefore be materially reduced. These tests, we may add, were rendered particularly severe by the fact that the alternators were run on light load and that compression was taking place in the engine cylinders which were not firing. In subsequent tests, the machines were paralleled in exact phase opposition, and also with one machine running at a speed 2 or 3 per cent below that of the other, without any ill effects, and, although this would be unnecessary under ordinary working conditions, it will be obvious that the normal process of synchronizing is an extremely simple matter.

In conclusion, it may be of interest to know that one of these alternators having a capacity of 210 kv.a. and directly coupled to a four-cylinder, semi-Diesel engine, has been installed at the works of the British Steel Piling Company, Limited, at Gaydon, near Ipswich. It is running satisfactorily in parallel with an ordinary synchronous alternator of the revolving-field type, driven by a single-cylinder gas engine. Hunt alternators have also been employed in hydro-electric power plants and an interesting installation of this kind, at a mill in Scotland, may be briefly referred to. In this case, during the winter months there is plenty of water available and the machine, driven by a Boving hydraulic turbine, runs as a generator in parallel with the supply company's mains, power being delivered to the town when the mill is shut down. During the summer, there is insufficient water to drive the turbine, and the alternator is then run from the mains as a synchronous motor, driving the mills and also improving the power factor. At other times, the supply of water varies rapidly, and the machine changes equally rapidly from an alternator to a synchronous motor, and vice versa, without any signs of instability, the change being noticeable only by the reversal of the energy meter. The most obvious application for the new type of alternator, however, is in connection with internal-combustion engines, since these machines can be driven by single-cylinder or two-cylinder engines, and operated in parallel without any of the difficulties experienced in running synchronous alternators in this way.

Possible Earnings Control Plant Additions

CAREFULLY ESTIMATED SAVINGS DUE TO PROPOSED IMPROVEMENTS WILL INTEREST PLANT MANAGEMENT. BY A. F. SHEEHAN

IN MAKING a request for some improvement in the power plant, the engineer oftentimes merely states the approximate amount of fuel that will be saved or adds technical details that serve only to confuse the management. The best way to do is, first ascertain the amount of money that must be invested, make an estimate of the interest and depreciation charges and in reporting to the membership, the engineer should state in clear, concise terms just what the financial return on the investment will be, instead of saying a lot of things about temperatures, pressures and B.t.u.

For instance, in one plant where I worked, the chief thought that an economizer would be an advantage and stated to the management that so much fuel would be saved for a given increase in the feed water temperature. When asked how long it would take for the coal saving to amortize the investment he was unable to produce definite figures. The flue gas temperature was only 475 deg. F. and if reduced to 300 deg. would effect a fuel saving of 8 per cent. The fuel bill was about $50,000 per year, coal cost $7.50 a ton and daily consumption was 23 T.

The plant was located in a paper mill and had a 400 hp. single cylinder condensing engine and two smaller engines of 85 hp., each driving paper machines. The total boiler load was about 16,000 lb. of steam per hour and the engines use 8000 lb. per hour, paper machine engines about 5000 lb. per hour, and the remainder was used in the bleaching room to boil rags, with the exception of the slight quantity of steam used by the boiler feed pump. The feed water temperature was around 150 deg. F. and the feed consisted of 5000 lb. of condensate from paper machines which utilized the exhaust of the small engines and 11,000 lb. of makeup water at 120 deg., taken from the hotwell. The feed pump exhausted into the open heater, which served as a receiving tank for the condensate which came from paper machines at 210 deg. F., 5000 lb. of condensate at 210 deg., and 11,000 lb. of makeup at 120 deg., gave an average temperature of about 140 deg., which was raised to 150 deg. F. by the exhaust of the feed pump.

Upon investigation, the cost of an economizer and forced draft fan was found to be $6500 and the company figured that the fixed charges and upkeep would amount to $1000 a year. Deducting $1000 from the estimated fuel saving of $4000 (8 per cent of $50,000) left $3000 as the annual return on the investment of $6500.

After considerable argument they decided against this policy, as the boilers were old and they did not care to spend this amount. It was then suggested to the chief that considerable fuel saving could be made by utilizing our present equipment to better advantage. It would mean a net loss to operate the main engine non-condensing just to heat the feed water. To utilize the exhaust from the paper machine engines in the feed heater meant that live steam would have to be used to dry paper and no coal would be saved by this method. In the plant was located an old Fitchburg engine connected to a 50-kw. generator which was formerly used to light the mill, but owing to the cost and trouble that the generator had given them when running, a new one had been installed three years previously and was belted to the main engine shaft. I suggested that the generator on this engine be overhauled and by running this engine for our lighting load, we could relieve the main engine of about 50 hp. and use the exhaust to raise our feed temperature to 212 deg. F. "That generator has been overhauled several times, already," he replied, "but the trouble is that it is too small to carry the load and will not run in parallel with the new one. Evidently the characteristics are different. And furthermore, in the daytime there would be no need to run it."

Next I suggested the plan of belting the engine to the main shaft and carrying as much load as we could, which would be between 50 and 60 hp. We sent in a requisition for a new 6-in. belt and then piped the exhaust into the open heater. After the belt arrived we located a 6-in.

pulley in the cellar and put it on the end of the main shaft, where it entered the machine room. There was a clutch between the machine room and the rest of the mill, to permit driving the largest paper machine from the main shaft in case of an accident to the small engine. The engine was then started with the clutch out, after removing the generator coupling bolts.

After the proper speed was reached, which required some experimenting, the clutch was thrown in. The weight on the governor lever of the main engine was moved inward just enough to allow the small engine to take about 30 hp. and then we noted the feed temperature. It was 205 deg., so we shifted more load to the small engine till the back pressure valve lifted. The load was then cut down just enough to stop the valve from opening and our feed temperature remained stationary at 210 deg. with the back pressure valve set at 2 lb. Of course the total steam output of the boiler was increased, as the small engine had a water rate of 28 lb. per hp.-hr. while the main engine water rate was only 18 lb. I figured the fuel saving as follows: The load on the main engine was reduced by 39 hp. and with an evaporation of 8 lb. of water per lb. of coal, this meant a saving of 74 lb. of coal per hour and even though the small engine used 1090 lb. of steam to develop 39 hp., 94 per cent of the total heat in this steam was returned to the boiler in the feed water so only 65 lb. of steam per hour (6 per cent $\times$ 1090) could be charged against the small engine or about 8 lb. of coal per hour. So there was a net saving of 66 lb. of coal per hour, 24 hr. per day, 300 days per year and at $7.50 per ton, the saving in a year's time would be $1782.

When the chief reported a fuel saving of $148 at the end of the month the management was interested, and inquired whether any further saving would be made without spending over a thousand dollars. They were willing now to invest that much provided that the entire sum could be returned in a year by the fuel saving resulting from the improvement. We told them that the fuel saving made by raising the feed temperature could be increased by at least a thousand dollars per year if we had another heater of the closed type to take exhaust steam from the small engine at 30 to 40 lb. back pressure and heat the feed water to 265 to 275 deg.

We promised to have all the necessary data as to cost of the heater and the exact fuel saving ready in one week and started at once to learn the cost of installing a second heater. From a manufacturer we got a price of $480 for a closed heater to heat 16,000 lb. of water per hour from 150 to 275 deg. The cost of pipe and valves and labor was set at $150.

We reported to the office that the total investment would be $630 and guaranteed a fuel saving of not less than $1000 a year. As this was equivalent to a dividend of 158 per cent, the manager ordered the heater at once. The total cost of heater, including piping and valves, amounted to $608 and we found that by loading the small engine as heavily as possible, we could maintain 39 lb. pressure in the heater which gave us an average temperature of 275 deg. F. The main engine load was reduced by 58 hp.

We had reduced the load by 39 hp. before installing the heater, so the gain due to this heater was 19 hp. At 18 lb. of steam per horsepower and an evaporation of 8 lb. the coal saving per day of 24 hr. came to 1026 lb. At $7.50 per ton the annual saving would be $\frac{1026 \times 300 \times \$7.50}{2000}$ or $1,154.00. The back pressure valve was set to open at 40 lb. and to prevent its opening, we ran a 1-in. pipe from the exhaust line to the paper machine where live steam was being used in some rolls to dry paper. This live steam was reduced from 150 lb. to 35 before entering the dryers and by passing the excess exhaust from the engine into these dryers the live steam consumption was greatly reduced. It required 1985 lb. of steam to heat 16,000 lb. of feed water from 150 to 275 deg. and the steam consumption of the engine sometimes exceeded this amount.

In several months the entire cost of the heater was returned. The possibility of using the exhaust from this engine in the paper machine had been considered before buying the heater but only about 800 lb. of steam per hr. was used at 35 lb. pressure and the power developed would not be enough to insure a close speed regulation, since the engine had a tendency to race at light loads. Also it could not be used with the exhaust of the two paper machine engines which supplied exhaust at 5 lb. pressure to the dryers as there would have been an excess. The paper machine engine supplied three-fourths of the dryers with steam, starting at the wet end of the machine, while the last few dryers at the other end were supplied with live steam at higher pressure. This arrangement of two different pressures was used in order to do as much drying as possible at low pressure, since more steam was condensed per sq. ft. of drying surface at the west end.

A total fuel saving of $2936.00 was made by diverting 52 hp. of the main engine load to a non-condensing engine and utilizing the exhaust, at a small investment, and while the economizer would have made a larger fuel saving, the return on the investment would have been less. In many industrial plants, it is useless to suggest an expenditure for improvements, unless the entire investment can be paid off in two years or less. But by careful analysis of conditions it is often possible to install equipment that will return its cost every year in fuel saving.

A. E. S. C. to Standardize Drafting Practice

ACCORDING TO a recent announcement, the American Engineering Standards Committee has been requested by the A.S.M.E. to authorize the organization of a sectional committee whose duty it would be to develop standards for drawings and certain drafting room practices. The society signifies its willingness to act as sponsor or joint sponsor for this project.

Drawing is the universal graphical language of the industrial world. It has its "grammar" and uses varied forms of expression and varied styles, matters of importance on which it is evidently advantageous to have general agreement.

Many industrial organizations in this country have been carrying on standardization work in this field and have prepared manuals of unusual significance. These drafting room manuals are more or less elaborate and complete as to the field covered by the standard practice. They standardize the conventions used on drawings, give the sizes of paper or cloth used, the size and style of lettering and grouping of notes, the arrangement of views, dimensioning, methods of expressing tolerances, instructions for alterations, classification of drawings and much other valuable information.

Care and Operation of Shell Type Brine Coolers

HEAT TRANSMISSION IS AFFECTED GREATLY BY QUANTITY OF AMMONIA IN CIRCULATION, DEAD LIQUID, OIL AND OTHER IMPURITIES. BY FRANK M. BENNETT*

THERE is little doubt that a shell and tube type brine cooler is the most efficient evaporative surface ever yet devised, provided it is properly installed and equipped with the necessary appurtenances to enable the operating engineer to get the maximum heat transmission possible and maintain that high transmission throughout the life of the cooler. Figure 1 shows how such a cooler is often installed.

Shell type coolers properly installed and operated will transmit from 80 to 100 B.t.u. per hr. per sq. ft., per degree temperature difference. In the same cooler, operating without sufficient liquid ammonia in it heat transmission will drop to less than 40 B.t.u.

If dead liquor and oil are allowed to accumulate in such a cooler heat transmission will be so little that practically

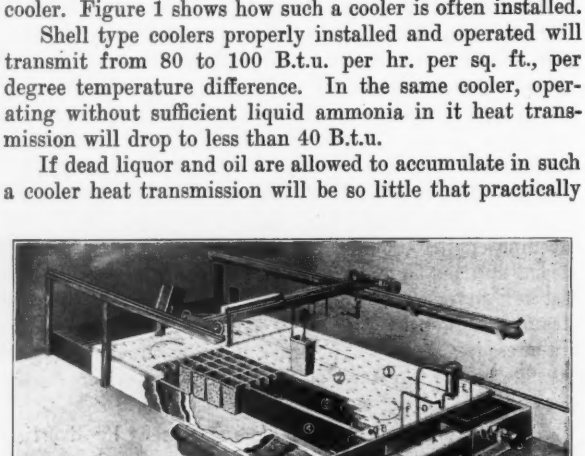


FIG. 1. TYPICAL ICE TANK LAYOUT, SHOWING INSTALLATION OF SHELL AND TUBE TYPE BRINE COOLER AND AGITATOR

no net result is obtained. The writer has actually experienced cases in which shell and tube brine coolers had been installed in an old plant where the ammonia charge had never been purified and, in the course of a few weeks, all the impurities in the entire plant had accumulated in the brine cooler and absolutely no refrigeration could be developed in the brine cooler, although the remainder of the plant worked better than it had before the ice plant with brine cooler had been installed.

In general form, a shell and tube brine cooler is exactly the same as a horizontal return tubular boiler. The ammonia is in the shell surrounding the tubes and the brine passes through these tubes. The ammonia takes the place of the water in a boiler and the brine may be compared to the gases of combustion in a boiler installation. The brine provides the heat to evaporate the ammonia out of the cooler and, of course, when the ammonia evaporates or boils it absorbs heat from the brine, cooling it to the desired temperature.

It will be noted that there is no high velocity of ammonia through the cooler as there is in a pipe coil. If there is dead ammonia or oil in a pipe coil, the velocity of the gas passing through the coil is high enough to pick up the dead liquor and oil and carry it along with the gas as entrained liquid, back through the suction to the compressor, thus keeping the dead liquor in circulation and enabling the plant to do some work. With the shell and tube brine cooler, any dead liquor or oil that enters the cooler will remain there, because there is no high velocity of gas to carry these impurities along with the good ammonia back through the suction line to the compressor.

Thus all impurities that may be in the ammonia system will collect in the brine cooler and stay there. The brine cooler acts as an ammonia purifier, boiling off the good ammonia and sending it back to the compressor, leaving

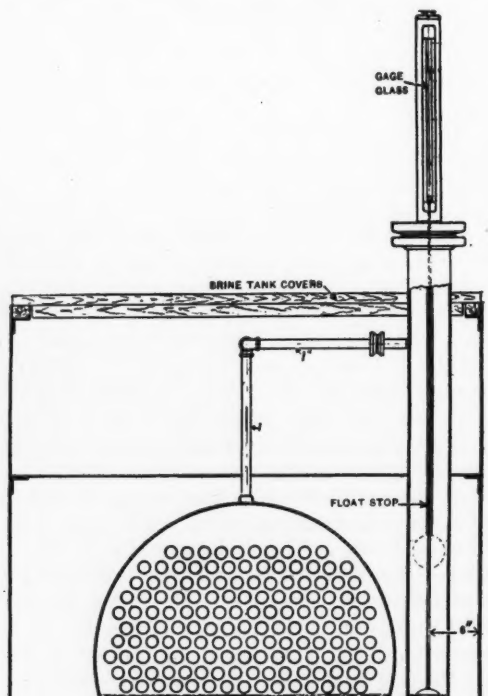


FIG. 2. THIS TYPE OF AMMONIA LEVEL INDICATOR GIVES ACCURATE INDICATION, AS GAGE GLASS IS NOT FROSTED

the impurities behind to accumulate at the bottom of the shell and tube cooler.

IMPURITIES MUST BE REMOVED FROM THE COOLER

To obtain continuous, efficient operation of the shell and tube brine cooler, therefore, it becomes absolutely necessary to provide some method of getting these impurities out of the cooler and out of the system. One type of cooler is equipped with an ammonia purifier which consists of a steel shell set below the brine cooler with a connection from the bottom of the brine cooler into the shell to drain impurities into the purifier. A warm water jacket around the purifier shell is provided to supply the heat to boil off the good ammonia, leaving the impurities in the purifier and a drain connection is provided for draining into a

*Engineer, The Arctic Ice Machine Co.

bucket. A suction connection from the top of the purifier leads into the main suction line of the plant and the good ammonia that is boiled off in the purifier is put back to work through this line.

To get maximum efficiency from a shell and tube cooler, it is necessary that the tubes be practically covered with liquid ammonia at all times. This high liquid level will, of course, cause some ammonia liquid to pass out of the cooler entrained with the gas, just as high water level in a steam boiler will allow water to pass over with the steam, causing wet steam. With ammonia, entrained liquid leaving the brine cooler is, of course, more dangerous than that leaving a foaming boiler, as the liquid carried back to the compressor will materially reduce its efficiency and at the same time endanger the compressor and the lives of the operators. To prevent this a suction separator and "S" trap can be put in the suction line from the cooler to return entrained liquid separated from the gas back to the brine cooler.

Gage Shows Accurately the Ammonia Level in the Cooler

We have stated above that the brine cooler must have enough ammonia in it to cover practically all the tubes. Until the last few years there has been really no satisfactory gage to indicate how much ammonia was being carried in the shell and tube cooler. It has, therefore, been the custom of some engineers to depend upon the suction temperature of the gas at the compressor as an indication of whether they were carrying sufficient ammonia in the brine cooler. Inasmuch as the suction temperature might be materially reduced by cold gas coming back from storage room coils or some other source, the gas temperature at the compressors was not a sure guide to the liquid level in the brine cooler.

Of course, most brine coolers have for years been equipped with a frost column which generally consisted of a piece of 3-in. pipe, hooked up in the form of a gage column and connected to the top and the bottom of the cooler. The height of the frost line on the 3-in. piece of pipe gave an indication of the height of the liquid in the shell cooler. As a matter of fact, however, this type of a gage column has proved to be inaccurate and of practically no value to the operator. Instead, there has been developed a positive float type gage column, which is illustrated in Fig. 2. This is connected to the brine cooler at the top and bottom so that the liquid level in the gage column is the same as in the shell cooler itself. A steel ball floats in the liquid in the gage column and by means of a piece of drill rod carries a cork indicator up into the gage glass that extends above the top of the column. There is no circulation of ammonia through the gage glass, consequently no frost prevents seeing the indicator and the operator has an absolutely positive indication of the height of the liquid in his brine cooler.

At a first glance the average engineer might object to the construction of this gage column owing to the seeming liability of ammonia loss in case the gage glass is accidentally broken. As a matter of fact, these gage columns are constructed using perfectly straight steel drill rod to carry the indicator cork; this drill rod passes through an orifice that separates the gage column from the gage glass, the orifice being only a few thousandths of an inch larger in diameter than the drill rod. Consequently, if the glass breaks there is a small area for ammonia to escape through and ammonia loss is so slight that a new gage glass can be put in without the use of a gas mask.

If the shell cooler is properly equipped with ammonia purifier, suction separator and gage column as described in this article, it can safely be depended upon to transmit 80 B.t.u. per hr., per sq. ft., per degree difference in temperature and to keep on indefinitely with this high efficiency. The life of a cooler should be longer than that of pipe coils if the cooler is properly constructed.

Good Mechanical Construction of Cooler Lengthens Life

Shell coolers should be made with a fire-welded shell so as to insure a shell whose longitudinal seam can be depended upon. The fire-welded shell is a product of the steel mill and is made just the same as pipe. In fact, it is nothing more than a large piece of pipe of lap-welded construction. Any other form of welded or riveted construction is likely to prove defective and may be responsible for a shell failure that will cause large loss of ammonia and serious damage to property and life. The shell cooler

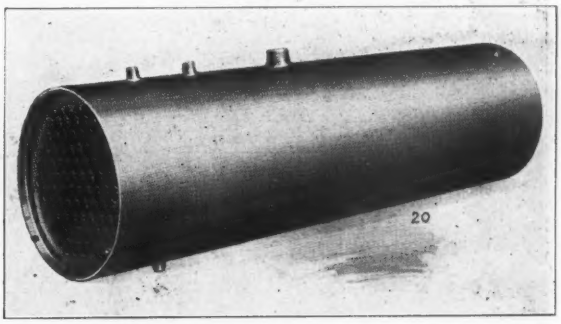


FIG. 3. BRINE COOLER WITH WELDED SHELL AND CHARCOAL IRON TUBES

should be installed with an expectation of at least 20 yr. life without repairs. The tubes should be not less than No. 12 gage material and must be of genuine charcoal iron. A cooler constructed in this way is shown in Fig. 3.

Ample tube surface is always advisable; 30 sq. ft. of tube surface per ton of refrigeration may be depended upon to operate with a 5 deg. temperature difference between the brine and the ammonia. Fifteen sq. ft. per ton of refrigeration would of course increase the temperature difference to about 10 deg. Assuming that the plant is operating at 185 lb. condensing pressure and that 15 deg. brine is required, a plant equipped with 15 sq. ft. of surface per ton of refrigeration would operate at 5 deg. ammonia or about 19.6 lb. gage pressure. The power consumption per ton of refrigeration would be about 28.25 kw-hr. per ton of refrigeration produced.

Equipped with 30 sq. ft. of brine cooler surface per ton of refrigeration, the plant would operate with 10 deg. ammonia to maintain 15 deg. brine, or a suction pressure of 23.8 lb. and under 185 lb. condensing pressure. The power consumption per ton would be a little less than 26 kw-hr. per ton of refrigeration produced.

By putting in 30 sq. ft. of brine cooler surface per ton of refrigeration, it is, therefore, possible to decrease the power consumption by 8 per cent and when paying the present high power rate the extra money is certainly well invested.

Heating Boilers Fired With Coal and Oil

MARINE TYPE WATER TUBE BOILERS SET WITH STOKERS UNDER EXTENDED FRONTS AND OIL BURNERS PLACED IN REAR WALLS OF FURNACES

CLEVELAND, O., can justly be proud of its new public library, the expenditure on which was $4,600,000, space having been provided for about 2,000,000 volumes.

All electrical current used in the building is purchased and the heating requirements are furnished by a boiler plant which is of unusual interest in that the furnaces were equipped to burn either coal or oil. The boilers were set with this in mind and both stokers and oil burners were provided for and installed in the original setting.

Approximately $10,000.00 was saved on the purchase of boiler equipment by using cross-drum, water-tube boilers which were made under war contracts for the U. S. Shipping Board. Although these boilers were designed

FIG. 1. BOILERS ARE FIRED AT THE FRONT END BY STOKERS

for high pressure service on board ship, they have been installed in this building for operation as low pressure heating units, the pressure carried being about 15 lb. ga. They are set about 2 ft. higher than is the customary practice, the rear header being 5 ft. 7¼ in. above the boiler room floor. Murphy stokers are set under the front end in extended furnaces formed by Detrick arches. The combustion space below the tubes is open the full depth of the furnace, the rear wall being vertical. Horizontal baffle tile laid on top of the lower row of tubes extend forward from the rear header about two-thirds of the furnace depth. Vertical baffles are arranged so there are three passes of the gas across the tubes.

It is an interesting fact that although the stokers are driven by means of steam engines no difficulty has been experienced with using 15 lb. steam pressure at the engine throttle. The engines are exactly the same as those used where high pressure steam is available for their operation.

Coal is brought to the building in motor trucks and chuted to a basement storage room. It is loaded by hand into a bucket which is wheeled to the boiler room where it is picked up by an electric hoist, weighed and pushed by hand, on a mono-rail track, to a point over the stoker hoppers where it is dumped. Ash is raked by hand to pits in front of the stokers. It is then shoveled into cans which are moved by hand a short distance to a mono-rail hoist which terminates at an elevator, on which the cans are delivered at the street level.

Each boiler is fired from the rear by means of five Hagan oil burners. The oil pressure is maintained at 275 lb. and the hole in each nozzle tip is 1/32 in. in diameter. It was found that smaller openings than these were easily clogged even with two strainers in the line. Oil

FIG. 2. MECHANICAL OIL BURNERS ARE INSTALLED IN THE REAR FURNACE WALL

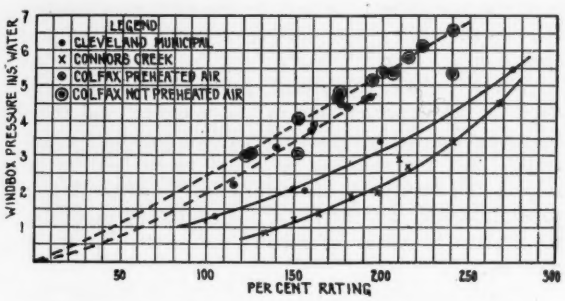
is stored in the building at some distance from the boiler room.

Miscellaneous boiler equipment consists of Bayer soot blowers, Hagan damper regulators and Hayes CO_2 and draft recorders. The building is heated by means of forced hot water circulation.

MERGER OF power companies is taking place with such rapidity that consolidations the magnitude of which would have attracted widespread attention a few months ago receive now but passing notice, says the Baltimore Sun. Efficiency and economy in operation are the moving factors back of these mergers, and it is a significant fact that the public accepts this explanation and sees in the process possibilities of better service and lower rates. It seems, in other words, that securities of public utilities are finally reaping the beneficial results of the now definitely established policy of public control of rates and service. Armed with this authority the public no longer fears the size of the utility. It acquiesces in mergers, no matter how large, as long as there is a check on abuse and exploitation. If these corporations have learned a lesson from the past and developed their plans, as they should do, with sound business judgment and with due regard for the interests of the public, the future would seem to hold out to them promise of permanent prosperity.

Determining the Shape of the Air Pressure Curve

I READ with considerable interest your article "Conditions Affecting the Use of Preheated Air" in the July 15 issue, pages 734-735, since I had recently been doing work of this nature for a friend and had come to almost identical conclusions regarding increased pressure loss through the fuel bed from a theoretical point of view. But on plotting the Colfax test figures as shown by the accompanying figure, it may be of interest to note that



AIR PRESSURE INCREASES FASTER THAN BOILER LOAD

the windbox pressure is actually lower with preheated than with cold air, probably due to the smaller weight of air required per pound of coal, since results showed higher boiler efficiency.

I cannot, however, agree with the shape of the curve shown in Fig. 1 of the July 15 issue, as practically all series of boiler tests at various ratings have shown the windbox pressure increasing more rapidly than the rate of combustion, making the curve concave upward as shown by the curves plotted from the Cleveland Municipal plant tests and those at Conners Creek, both of which were carefully conducted. Similar results were shown by the original Delray tests.

While the results of the Colfax tests are possibly open to the interpretation of a curve convex upward, the range covered is hardly wide enough to make this a certainty, nor is the deviation from a straight line greater than the variation between similar tests so that probably the fairest interpretation is to carry a straight line through the points as far as they go and wait for experimental data before extrapolating at either end. It should be noted, however, that these curves must become concave upward to reach the origin.

One of the conditions which tends to cause the pressure-rating curve to flatten from the parabola which might be expected is that, at lower ratings, results may be obtained with a rough irregular fire of greater than average resistance. This requires more air, since such a fire cannot utilize air to the best advantage, thus disproportionately increasing the windbox pressure, whereas, at the higher ratings in order to burn sufficient coal to obtain the desired capacity, the fire must be thin, open and uniform. This will effect combustion with a minimum of excess air and the decreased resistance and lesser quantity of air will reduce the windbox pressure to points almost directly proportional to the load developed.

Another noticeable feature with low loads and small pressures is the chimney effect of the hot gases in the fuel bed. This may amount to almost 0.02 in. of water per foot of thickness of fuel bed, or furnace height, if the over-fire draft is not measured immediately above the fuel bed. This tends to reduce the draft resistances at low capacities more than at higher ratings and tends to straighten out the experimental curve. So it seems likely that the orifice law holds for any one fuel bed but is obscured by varying conditions.

New Haven, Conn. H. D. FISHER.

(Editor's Note—Curve shown in Fig. 1, July 15 issue, although not so stated, shows air pressure for traveling grate stokers. Curves discussed in this letter are for underfeed stokers. Physical characteristics, moisture and caking qualities of the coal must also be considered.)

Operating Engineers Must Learn Salesmanship

IN THE July 1 issue, Mr. Sheehan presents the case of a paper mill in Holyoke where all equipment, including the paper machines themselves, is motor-driven, operating on current generated by a 600-kw. condensing steam turbine. All process steam needs, even for paper drying, are supplied through a reducing valve directly from the boiler.

Mr. Sheehan points out the poor logic of this and shows that the installation of a steam unit to carry a portion of the electric load and supply process steam would save several thousand dollars a year over the present operation or over a proposed plan to buy power.

There is no question but that the plan suggested by him is the most logical, the most economical of coal and of dollars, and altogether the most satisfactory. He says, ". . . . and yet hundreds of paper mills and other industrial plants have overlooked this great possibility when trying to reduce their power costs."

I agree with that but I sometimes feel that the fault lies equally with the plant designers and the plant owners. The engine is often felt to be a type of equipment fast becoming obsolete, while the turbine is "modern." The designer feels satisfied in installing a dependable piece of equipment like the turbine and the owner cherishes a secret pride (although he might not be willing to admit it) in coming into his power plant and seeing his turbine silently turning out power, without making the fuss that

usually goes with a reciprocating unit. The fact that the engine might be more profitable may be a secondary matter to the pride of having a turbine. Not a common sense view, you say. Maybe not, but it's human nature, all the same.

Mr. Sheehan also says, "If this plan were aggressively pushed by manufacturers of power equipment, the effect on production costs in many industries would be quite pronounced."

I do not agree with him as to the proper source of the "pushing." I think that the engineer in charge of the power plant is the man to do the pushing. The manufacturer's salesman is first of all looked on with suspicion because he has an "ax to grind." The plant engineer has no ulterior motive and only seeks the best interests of his company.

Again, before the salesman can effectively present to the best advantage, such a case as the one discussed, he must have all the facts. That means that he must make a study of the individual case, must have access to all the records and must become thoroughly familiar with the plant's needs. The salesman who can inspire such confidence is rare indeed.

But the engineer is right on the ground, has the figures at his fingers' tips and knows every demand and need of the plant. Why isn't he in a better position to start such a campaign than anyone else?

In the first place, the engineer must realize that this is a "selling" job. Too many operating men wait until someone else has initiated and completed a power plant change, and then complain for the next few years that they weren't consulted and that if they had been they could have told the boss a much better way to do the job.

When a salesman is being trained, he is told that virtually every sale must be the result of following a well defined procedure. He must gain a hearing, then he must arouse the prospect's interest in what he has to offer. Then he must create a desire to buy and finally he must work up this desire to the "sign on the dotted line" climax.

In selling his plan, the plant engineer will have to follow pretty much the same scheme. It should be easy for him to gain a hearing. He can present his case verbally or in writing. Where it is feasible, the latter method is best because then the facts are all down in black and white; if the boss lays the proposition aside for a few days to think it over, he can refer back to it and refresh his memory instantly.

When he writes his story, the engineer must arouse his boss's interest, create the desire and at least proceed to considerable length toward finishing the job. This presupposes that the engineer knows his business, that he keeps intimately in touch with the latest developments in power plant practice by reading the current journals and that he keeps the needs of his own plant in mind as he studies descriptions of other power plants where improvements and economies are being made.

It also presupposes that the engineer knows enough about business and a few simple economic principles to realize when the purchase of even an exceedingly efficient piece of power plant equipment may be poor business from the standpoint of the company's pocketbook. He must also know how to include in his calculations the proper charges for interest on the investment, depreciation of equipment. These are only matters of arithmetic, but they are important.

Above all, the engineer must remember to talk only the language that the boss understands. Total heat of the steam, conversion efficiency and equivalent evaporation—these terms are part of the stock in trade of the engineer, yet to the average executive they are only a meaningless jargon of words. The engineer must omit all this language, and if some engineering terms must be used or explained, use the simplest words and the clearest explanation possible.

For instance, the case discussed by Mr. Sheehan would have to be entirely re-written if it were to be presented effectively to a business executive. A lot of the technical terms would have to be changed or left out altogether, otherwise the boss would be completely nonplussed. Then the recommendation would probably die a natural death.

It might often be best to hold in reserve a few of the arguments for the proposition, and about a week later write again, present these arguments, and briefly sum up the advantages to clinch the matter and bring about a favorable decision.

When the engineer can estimate approximate costs of buying and installing the equipment, and of operation, then he can make the comparison between the proposed plan and the present method, in the form of a tabulation, and can show the dollars and cents profit over the present operation.

If the engineer can present a few plans for new equipment or for improvements in this manner, and the boss finds that his engineer has estimated somewhere near correctly, then the engineer is bound to be held in better respect and eventually his reward will be of the kind that pays dividends. Furthermore, the engineer's opinions will more often be asked beforehand rather than at the post-mortem.

North Glenside, Pa. W. J. Risley, Jr.

Careful Study Necessary When Insulating Pipes

It is generally appreciated that a bare steam pipe represents costly radiation losses and consequent wet steam. General practice calls for insulating all such lines. Operators are, for the most part, agreed as to the general needs of insulation, but in a recent visit to a number of boiler plants the writer was impressed by the apparent difference of opinion as to where insulation is needed and what kind is required for best results.

One plant displayed an insulated flue gas breeching, a feed water heater, a boiler, and low and high pressure lines. In fact, all heat radiating surface was covered. Another plant selected only high pressure steam lines as worthy of consideration. There is always a happy medium which should apply.

Steam to prime movers should, of course, be as dry as it is economically possible to get it. Accordingly it is entirely proper to apply insulation to the main supply line. In fact, it is safe to say that all steam lines except such as discharge to atmosphere should be insulated.

There are cases, however, when a steam line running through a building which requires additional heating, may well be left bare. This applies to feed water heaters and other exposed surfaces. It is for the engineer to decide whether or not his saving in coal will be greater if he insulates exposed heat radiating surface, and then proceeds to install steam coils to heat the building; or simply uses

the radiated heat for this purpose. I believe the subject of insulation is not given sufficient consideration. A good insulation job looks nice and it often makes an impression to be asked to hold one's hand on a flue carrying 600 deg. F. gases and to note that the outside of the covering is only warm.

So much for promiscuous application. Next, what kind of insulation should be applied, how should it be fastened, and why? Here again the engineer must stop long enough to analyze conditions. Magnesia is accepted as a good insulator, but whether or not double thickness is required is for the engineer to determine. Sponge felted covering is more durable and efficient on lines which vibrate. When fastening covering, steel bands should not be used where covering is exposed to moisture. Use cement. Eight ounce canvas, as ordinarily furnished, will disintegrate in a short time if exposed to moisture or heat. After taking pains to insulate a pipe carefully, don't use it for a walk-way to close a valve and if it is necessary to replace a covered valve or fitting, take time to replace the covering. When pipe covering gets loose and baggy, fix it up and take the time to do it properly.

This article is not intended as a set of rules and regulations, but merely to bring to the attention of readers the fact that insulation should be given as careful consideration as other power plant problems.

Lincoln, N. H. A. P. NUTTER.

Opportunities Are Often Overlooked

WHAT EXASPERATES me most is to hear an engineer lamenting the lack of opportunity for advancement in a plant where he is already chief engineer. Bill Smith was of that sort and at last he became such a pest that the superintendent told him to look for another position and Jim Jones was employed to take over the work.

Jones soon learned that all his assistants and even the superintendent held the idea that the plant, which contained considerable equipment, was hopelessly overloaded. They were of the opinion that the only hope for relief was the installation of more boiler and engine capacity, since the steam would persist in losing pressure in spite of all the firemen could do.

This was several years ago. When Jones was employed, the superintendent told him to take entire charge of all mechanical equipment, which included shop machines and line shafting as well as the power plant. His only instructions were to do his best to keep things moving.

Jones was a live wire and a hustler who knew his business. One of the first things he asked for and received was a good engine indicator. Next, mechanical tube cleaners for the boilers were given him. He set his assistants realining the workshop shafting, repairing worn shaft bearings and putting the belting into proper shape so that the work would be done with the least possible loss of power. He also stopped many other minor power leaks by replacing worn-out pump valves and installing new piston rings or packing where needed. As a result the equipment is producing 25 per cent more work with considerably less steam. Much of this power saving has been due to less friction in the shafting and there has been no trouble in delivering the required power with the old equipment. The helpers and firemen have an easier time and are always on the alert to make savings.

Such are the conditions in this plant of which Jim Jones took charge after Bill Smith had decided there was no more room for improvement or advancement. Smith didn't have the right perspective. He failed to see the opportunities which were just in front of him. He blamed the superintendent for not helping him, yet that same superintendent not only gave Jones the heartiest kind of co-operation but he told the owner of the excellent work which Jones had done and a substantial increase in pay was given him.

I am sure that a large majority of plant owners and superintendents are ready and willing to give all credit to engineers who show by their actions that they have the interests of the owner and the welfare of the plant at heart.

Toronto, Canada. J. THORN.

Back Pressure Caused Chattering Safety Valve

IN THE July 15 number the article in "Questions and Answers" was perhaps the most comprehensive and easily understood of any I have ever seen on the safety valve and it leads me to write of experiences I have had which may be of help to young engineers and perhaps to some no longer young.

Some time ago I removed a safety valve to send to the shop to be ground in. When it returned it worked perfectly, but shortly after, it refused to blow at 105 lb., the pressure at which it was set to blow. I tied a cord to the lever and instructed the fireman to pull it whenever steam pressure reached the blowing point, hoping that he would not fall asleep.

As soon as I could do so I removed the top of the valve and was much surprised to find that even with the aid of city water pressure of 70 lb. I could not remove the valve disc. Finally I cut a shallow thread in a length of inch pipe and by screwing it in to the top of the disc I eventually was able to remove it from the valve. I found that, for some unexplained reason, the guide vanes had become expanded enough to bind in the ring in which they move and a few strokes of a file was all that was needed to remedy the difficulty.

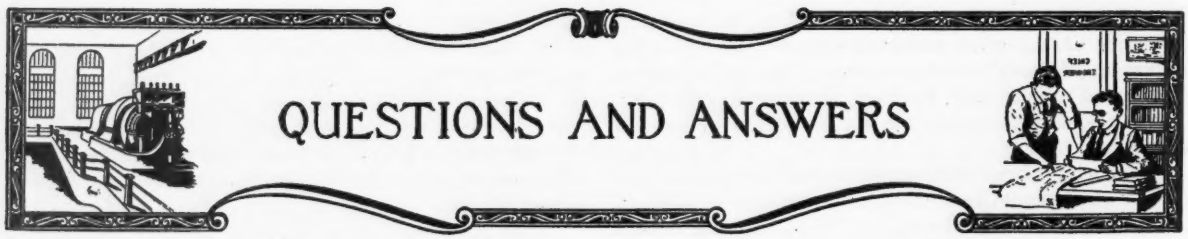
I have often wondered at what pressure it would have let go had the fireman not proved conscientious with the string.

Did you ever have a chattering safety? Isn't it a disagreeable thing to have around? I had one and when it let go it fairly shook the ground. The neighbors all ran to the windows and outdoors to see if the boiler had blown up. Fortunately it only had the trick when I set the pressure 5 lb. higher. It worked all right at 100 lb. but at 105 lb. it fluttered like a Liberty motor. So I had to keep the pressure lower than desirable on this account. But a tip from an inspector soon put an end to my troubles. I simply removed the pipe and let it blow into the boiler room.

I assume that the pipe caused a back pressure sufficient at certain pressure to allow the disc to reseat itself partly, then immediately opened, and the rapid action made the fluttering and vibration.

A safety valve opening directly into the boiler room has other advantages. To avoid the noise and dust a fireman will cut his rest short and take measures to prevent it.

Keene, N. H. ARTHUR H. PARKER.

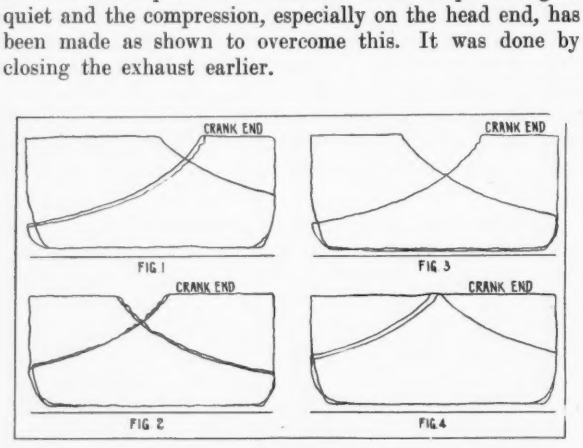


How May the Cards Be Improved?

IN THE accompanying figures are shown four indicator cards which were taken on a 28 by 48-in. Hamilton Corliss engine which has been fitted with the Nordberg long range valve motion.

They show progressive steps in adjustment of cutoff cam rods to even up the load which on card No. 1 was too great on the head end. No. 2 shows too great a change. No. 3 is still in error, the alteration being carried too far. No. 4 is about even and shows peak load conditions which are about this way most of the time.

Steam pressure was 110 lb. gage, back pressure 5 lb., rod diameter 4½ in., 50 lb. spring, 32 r.p.m. Under this load and back pressure it was difficult to keep the engine quiet and the compression, especially on the head end, has been made as shown to overcome this. It was done by closing the exhaust earlier.



INDICATOR CARDS OF CORLISS ENGINE, READING FROM FIGS. 1 TO 4, SHOW PROGRESSIVE STEPS IN ADJUSTMENT OF CUTOFF CAM RODS

Please tell me whether there is any way to improve operation further, as shown by the cards. I need more power and less noise and have other uses for steam, coal and money. H. K. S.

Feed Water Should Have Scientific Treatment

OUR BOILER is in service for 8 mo. of each year and cannot be washed out during this time. Lime forms on the shell. Is it all right to treat this boiler with potatoes? Do they injure the boiler in any way? W. G. H.

A. The use of potatoes in a boiler is a makeshift affair and should not be encouraged. Potatoes are mostly starch and water and there is no reason why there could be any chemical action when these are introduced into the boiler.

We would earnestly suggest that you obtain a sample of the scale from your boiler and also a sample of the raw water and submit them to a firm specializing in the treatment of boiler feed water. When used with a small boiler, such as you have, the apparatus for introducing the compound into the boiler is very simple and inexpensive and you will find that elimination of this scale will give you a much better heat transfer and the subsequent saving of fuel.

How Much Additional Steam Is Needed?

WE ARE at present using 15,400 lb. exhaust steam per hr. for process work at 6 lb. pressure. This is obtained from apparatus having a water rate of 55 lb. per hp-hr., but we will soon install an engine with a water rate of 35 lb. per kw-hr. The initial steam pressure is 115 lb. gage. It is evident that 440 kw-hr. will be derived from this 15,400 lb. steam, but the result will be that a smaller number of heat units will be discharged to the exhaust line, since more heat will be taken out and transformed into work by the new engine. In order to maintain the same exhaust pressure and do the same amount of process work as at present, what must be the load on the generator? H. K. S.

A. With the present steam consumption of 15,400 lb. per hr. and 115 lb. gage, there is 1191 B.t.u. total heat in one lb. of steam. $15{,}400 \times 1191 = 18{,}341{,}400$ B.t.u. With a 55 lb. water rate per hp., there is $15{,}400 \div 55 = 280$ hp. generated. Since the heat equivalent of 1 hp.-hr. = 2546 B.t.u., $280 \times 2546 = 712{,}880$ B.t.u. transformed into work. $18{,}341{,}400 - 712{,}880 = 17{,}628{,}520$ B.t.u. discharged into the exhaust at present.

Since you still wish to discharge this much into the exhaust, if you use an engine with a water rate of 35 lb. per kw-hr. with 15,400 lb. steam, you will generate $15{,}400 \div 35 = 440$ kw-hr. Since the heat equivalent of a kw-hr. = 3411 B.t.u., then $440 \times 3411 = 1{,}500{,}840$ B.t.u. transformed into work. $18{,}341{,}400 - 1{,}500{,}840 = 16{,}840{,}560$ B.t.u. discharged into the exhaust under the proposed conditions. Then $17{,}628{,}520 - 16{,}840{,}560 = 787{,}960$ additional B.t.u. needed in the exhaust to do the same amount of work as before. Since the exhaust steam has 1157 B.t.u. per lb., then $787{,}960 \div 1157 = 681$ lb. additional steam needed. With a water rate of 35 lb., $681 \div 35$ lb. $= 19.5$ kw-hr. more load on the engine; $440 + 19.5 = 459.5$ kw., which should be the load on the new engine to give you the same conditions of exhaust steam for process work as at present.

What Is the Furnace Temperature?

IF PURE CARBON is completely burned, what is the temperature of the products of combustion if the fuel has a heat value of 14,544 B.t.u. per lb., there is 21 lb. gas per lb. of fuel, the specific heat of the furnace gases is 0.24, and the temperature of the air entering the furnace is 70 deg. F.? G. F. A.

A. We arrive at the temperature of the products of combustion by the following formula:

$$T = \frac{\text{B.t.u. in 1 lb. of fuel}}{W \times S}$$

where,

T = the temperature of the furnace above the air temperature.

W = the weight of the products of combustion per lb. of fuel.

S = the specific heat of the products of combustion.

We then have

$$T = \frac{14{,}544}{21 \times 0.24} = 2880 \text{ deg. above the air temperature.}$$

2880 + 70 = 2950 deg., the theoretical temperature of the gases in the furnace.

How to Determine Boiler Efficiency

AN ANALYSIS of coal used in a boiler test gave the following results: carbon, 80 per cent; hydrogen, 5 per cent; oxygen, 4 per cent; nitrogen, 2 per cent; ash, 9 per cent. There was 4000 lb. of coal used per hour to evaporate 25,000 lb. of water. Feed water temperature was 100 deg. F. and the steam pressure, 100 lb. absolute. Find the efficiency of the boiler. C. M. S.

A. Your question is not complete. You have given the ultimate analysis of the coal, but have failed to state the heat value, which is the most important thing in determining efficiency. An ultimate analysis is necessary in figuring a complete heat balance, but is not necessary for obtaining efficiency.

On the basis of similar analyses reported by the U. S. Bureau of Mines in Bulletin No. 22 we have assumed a heat value of 14,000 B.t.u. which should be quite close. You have also failed to state the quality of steam. We have therefore assumed it to be dry saturated steam.

The first step is to determine the actual evaporation. This is found by dividing the total amount of water evaporated per hour by the amount of coal burned. This gives 6.25 lb. water, actual evaporation per pound of coal.

The next step is to determine the equivalent evaporation. In order to arrive at this, the factor of evaporation must first be determined. This may be found by the formula: $F = \frac{H-h}{970.4}$, in which F = the factor, H = the total heat in the steam above 32 deg., and h = the sensible heat in the feed water above 32 deg. At 100 lb. absolute pressure, from steam tables we find 1186 B.t.u., total heat in the steam. With a feed water temperature of 100 deg. there is 68 deg. sensible heat above 32 deg. Then (1186 — 68) ÷ 970.4 = 1.15, factor of evaporation. Multiplying 6.25 by 1.15 we have 7.2 lb., equivalent evaporation. (7.2 × 970.4) ÷ 14,000 = 49.7 per cent efficiency.

Reason for Leaky Check Valve

REPLYING to the inquiry "What Causes Leaky Check Valve?" page 761, July 15 issue, may I state that if Mr. Rutledge were to reduce the size of the check valve on No. 2 boiler he probably would experience the same trouble as with No. 1 boiler check valve. Therefore, it is reasonable to assume that if No. 1 boiler is a better steamer than No. 2 boiler there would be more water evaporated per hour than in No. 2 boiler. This would show that the capacity of the check valve on No. 1 boiler is being worked beyond its limit and is the cause of the leak.

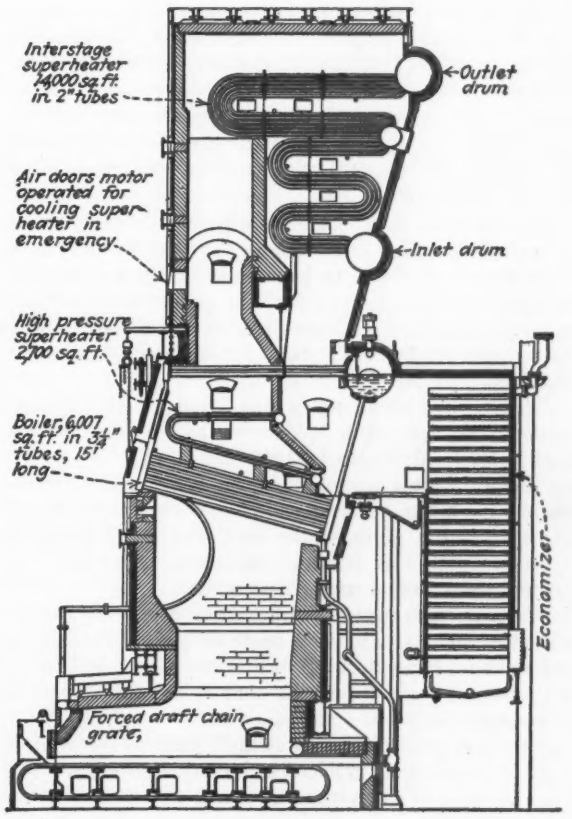
Overworking the valve disc, especially at an increased pressure and temperature over that to which the body is subjected (the outside of the body is at atmospheric pressure and temperature), will cause expansion of the disc. This will cause it to bind and so allow part of the water from No. 1 boiler to leak past into the No. 2 boiler and part to surge back and forth in the feed line in unison with pulsations of the pump, thereby causing the irregular temperature noted on the chart.

Chicago, Ill. E. S. KIMMEL.

Reheat Boiler Same as Regular Type

WHAT IS meant by a reheat boiler? C. B.

A. Reheat boilers, whose main function is to reheat the exhaust steam from high pressure turbines, also produce steam and, in general, are no different from other boilers except for an additional superheater. As shown in the drawing, inside the reheat boiler setting above the regular superheater, there is usually placed another coil or series of coils through which exhaust steam from the turbines is passed. This coil really has no connection with the rest of the boiler and is a separate superheater.


Interstage superheater 14000 sq.ft. in 2" tubes
Outlet drum
Air doors motor operated for cooling superheater in emergency
Inlet drum
High pressure superheater 2700 sq. ft.
Boiler, 6007 sq.ft. in 3¼" tubes, 15' long
Economizer
Forced draft chain grate

REHEAT BOILER SETTING. INDEPENDENT SUPERHEATER AT TOP REHEATS EXHAUST STEAM FROM TURBINES

EDITORIAL COMMENT

Research and Power

So consistently are the results of research changing the practice in power generation and transmission that no sane power engineer would question its value.

Within a decade we have seen pulverized coal furnaces, mercury turbines, 220,000-volt transmission, automatic and remote control generating and sub-stations come into use, to say nothing of hundreds of lesser changes and improvements, all made possible and developed by research.

Not so evident is the bearing of research in chemical, metallurgical and other fields on the solution of power problems, but it is none the less vital. Success with superheated steam and high pressures rests basically on proper materials for prime mover parts and piping. Steel castings are ancient history but the proper alloys of nickel to give strength and toughness, chromium to give hardness and the right heat treatment to insure uniformity are comparatively recent knowledge developed by research. Manganese is another element which strengthens and hardens steel and by varying the composition of the alloy almost any quality desired can be secured, giving parts often superior to forgings.

Now comes a development which seems at the moment to have no practical use. Copper, so cast as to form a single crystal, is found to have an electrical conductivity lengthwise of the crystal 13 per cent greater than ordinary copper. Such a crystal is soft like wax and loses its conducting value if bent. Crystals up to 6 in. and one 14 in. long have been produced.

This doesn't sound much like a long distance transmission line,—yet. But, hold on! The real development of alloy steel only began in 1910 and it was only 20 yr. ago that De Forest accomplished wireless telephone transmission for about a block. Now your 10-year-old boy is disgusted if the radio set he has built won't bring in everything within a thousand miles and programs from London are promised us for next winter.

When research gets at work on this copper crystal development and starts to tie it up to alloy combinations, we may wake up some morning to find our economical radius of transmission boosted 10 per cent or our line losses cut 10 per cent.

Chemical research? It is at the bottom of the solution of every combustion problem and every feed water problem. In spite of our progress, we are still clumsy in the conversion of heat energy into electrical and mechanical equivalents. Some day,—any day,—the research worker may find the key to unlock direct conversion from heat to electricity. It isn't yet in sight, but, if it comes, it will be likely to scrap all our present heat-driven prime movers.

Power engineers must keep posted on research results both great and small—those seeming to have direct value and those seemingly of remote interest. There is hardly a field of science in which a new discovery may not have possibilities for application in power work. There is no power plant engineer who may not perceive the possibility and application of such a discovery if he is alert to find it.

No Cause for Alarm

Every week brings in news that one or more of the big utility companies has extended its holdings by purchasing controlling interest in smaller or local utility companies. The advantages of interconnecting power plants have become evident to the financial interests. A single power plant cannot compete with a chain of plants.

This tendency towards centralized control is causing alarm in some quarters for fear that the power industry will become an uncontrollable monopoly, capable of imposing unjust rates upon the public.

It must be recognized that for highest economy, the production and distribution of power is most satisfactorily accomplished when only one system serves the community, thus virtually giving a monopoly to one company. In return for this monopolistic right the general laws of the country now in effect require the company to operate under the provisions of a franchise granted by the political representatives of the city. In addition, the utility companies are required by the Public Service Commissions of the various states to report their earnings and secure permission to increase capital or float bonds. With this information available, the commissions establish rates which the companies are permitted to charge. In the case of hydraulic projects, the utility owners meet another regulating body, the Federal Water Power Commission.

With all these checks on the privately-owned utilities we need have no fear that the stocks will be watered, the utility earnings exorbitant or the rates unjust. The governments, federal, state and municipal, virtually have control of the utilities, but do not assume financial responsibility for their success or failure.

Broaden Your Experience

Knowledge based upon experience can be obtained in two ways, that is, either through the agency of personal experience or through observance of the experience of others. Of the two methods some people will contend that personal experience is the more valuable, which is true within certain limitations. It is not to be expected that a cigar store clerk could read technical literature in his spare moments and eventually become capable of engaging in important engineering work. He would lack that familiarity which is gained only through personal contact with the general field of operation.

Suppose, on the other hand, that we were to place an ambitious young man in a field in which he was thoroughly interested but, at the same time, exclude contacts which would afford to him the experiences of those who had already gone over the same field. Assume further that his interest was diverted toward the use of steam for producing mechanical power. Under these circumstances it would be necessary for him to start with the developments of Watt and follow on through to the design of a 70,000-kw. turbine unit. It is evident on the face of it that this could not be done because the element of time, contemporary dis-

coveries and the pitfalls of others would be unknown to him.

These suppositions emphasize the advantages which are now available to both the student and the experienced engineer. It is at once apparent that there must be some means of knowing what has been accomplished and what methods or practices have proved unsatisfactory. Life is too short for each engineer to hunt over the field and ferret out others who have done work along the lines in which he is interested and it would be a still greater impossibility for him to find these men and through personal contact get the information he desired.

For these reasons it will be found that the most valuable men in the profession are those who not only practice engineering but who avail themselves of the experience of others. They build on to the structure where the other man left off. They have neither limited their experience to their own field of operations nor to that of a few of their acquaintances but they have greatly enlarged their experience by adding to it the knowledge of the entire profession. This has been accomplished through study, the elements being obtained principally from books, whereas the applications have been obtained from technical publications which are in fact a great clearing house for the dissemination of the accumulative experience not of a few, but of the entire profession.

Off Duty

Up on top of a barren mountain 5000 ft. high, in the desert region of Arizona where rain seldom falls and where the winds blow unceasingly, stands a small adobe building. Unattractive, sheathed in sheet iron to protect it from lightning, it stands alone, far removed from the comforts and pleasures of civilization, exposed to all the fury of the elements. It has not much to offer as a place of abode; few, indeed, would choose it as a place to live in the year 'round, yet the man who occupies it apparently is contented and pursues his work up there with unceasing devotion. It is the Mt. Harqua Hala Solar Observatory of the Smithsonian Institution.

Almost five thousand miles distant on another mountain peak in the bleak nitrate region of Chile is perched a similar station, this, the Montezuma Solar Observatory also of the Smithsonian Institution. Here, too, a lone observer spends his time the year 'round gathering scientific data.

Though separated by thousands of miles on opposite sides of the earth, so to speak, these two stations function as one. Every day the respective observers make determinations of the intensity of the sun's heat and telegraph them to the Smithsonian Institution at Washington, where they are interpreted in terms of atmospheric values. These in turn are used as a basis for predicting the weather conditions in New York City, months in advance.

Now, the most astonishing thing about all this is not the fact that solar radiation influences the weather—that could have been suspected—but that the relation between the minute variations in solar radiation and weather were discovered and correctly interpreted. How this discovery came about, though it forms an intensely interesting story, cannot be recounted here. It is only another one of those accounts, the history of science is replete with them, which bespeak years of painstaking observation and patient research. The observers at these two observatories are typical of scientists the world over. Their names never appear on the front pages of newspapers, yet they spend their lives searching out nature's secrets so that humanity may benefit. They ask no reward except that satisfaction which the pursuit of their work brings them.

These men of science, working at the very forefront of human knowledge, wearing out the best years of their lives in the unending search for truth, cannot be regarded too highly. At the recent evolution trial in Tennessee, Mr. Bryan and his associates made no effort to conceal their contempt for "science and learning" and depicted the scientist as a wicked individual who they claimed was robbing man of his sublime ancestry. It is not our desire to become involved in a discussion of evolution and religious belief, indeed in our opinion these two questions are entirely apart, but we would like to ask those who ridicule and discredit the work of the scientist, whether man is not being robbed of all sublimity now, when he is denied the privilege of searching out nature's innermost secrets? For when does man rise to greater dignity than when a Galileo, a Newton, an Einstein or a Pasteur makes some part of the universe more intelligible?

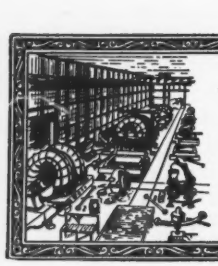
Have they ever stopped to consider the quality of soul that is needed to induce a man to work 40 years in the laboratory over a microscope and then give his results to all mankind without asking a penny for himself?

Have these people who so grossly misrepresent the efforts of the scientist ever given thought to the work of, say, Frederick Wilhelm Herschel, who with his capable sister so unremittingly gave his lifetime to laying the foundations of modern physical astronomy? How Herschel, a poor German musician emigrating to England and there with telescopes he himself constructed threw the heavens into a new light and for the first time revealed to the eyes of mankind a new starry universe of resplendent beauty? Herschel transformed a cold, changeless sky into a luxuriant garden, as it were, alive with motion and color. He imparted life to the heavens. During his life, he catalogued thousands of stars, among which were 800 double stars and over 2000 nebulas. It was Herschel who determined a motion in the solar system as a whole towards a point in the constellation of Hercules. In 1781 he amazed the scientific world by discovering Uranus, a new planet, beyond Saturn. England smiled upon him before he died and knighted him—Sir William Herschel.

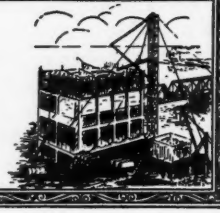
The story of Herschel's life is typical. We might cite Faraday, Hemholtz, Jenner, Pasteur and endless others whose lives were similarly spent but space does not permit.

In our own day, do these people who malign science ever stop to think of the courage required to spend one's life in the X-ray laboratory searching out the secrets of these deadly rays—of the unhealing burns produced which result in amputations of fingers, hands, arms, and loss of sight and finally lead to death? Of late years several noted scientists have met slow, tortuous death in the X-ray laboratory trying to rid humanity of cancer. These are the wicked scientists who are robbing man of his sublimity!

When all is considered, to contribute successfully to the progress of science requires more integrity of mind, more purity of heart, more unselfishness, more devotion, more unworldliness, in fact, than any other kind of human activity. The work is harder, the standards are higher, and the discipline more rigorous than men like Bryan have ever dreamed of demanding of themselves. Furthermore, if the human reason has any purpose which may be called divine, that purpose certainly is the full, free and fearless use of reason to understand the system of the universe.



POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Pit No. 3 Hydro Plant Completed

FOURTH UNIT OF PACIFIC GAS & ELECTRIC CO.'S $100,000,000 PIT RIVER PROJECT DEVELOPS 108,000 HP. BY J. CHARLES JORDAN

PRIOR TO THE completion of the Pit No. 1 plant, Sept. 30, 1922, surveys and preliminary details were arranged for the construction of the Pit No. 3 plant. This plant was built following Pit No. 1 because the growth of the demand for electric energy indicated that a block of power equivalent to that available from this Pit No. 3 plant would be needed about July, 1925. This project is rather more complicated than the Pit No. 1 as it not only involved the construction of a considerably greater length of tunnel but also required a larger dam. In order to facilitate the work a railroad 11 mi. in length was constructed as a branch to the Pit River Railroad, running from Cayton Valley to the Pit No. 3 power house site. This railroad passed the dam site so it became available for hauling material and supplies for the entire project. Pit No. 3 development begins about 2 mi. below Peck's Bridge.

DAM IS 125 FT. HIGH AND THE SPILLWAY, WHICH IS 270 FT. LONG, WILL PASS FLOOD WATERS AT THE RATE OF 70,000 SEC. FT.

At this point a diversion dam, 125 ft. in height, backs up the water for about 10 mi., to the proposed location of the Pit No. 2 power house. The surface of the reservoir created by this dam is 50 ft. above the floor of Peck's Bridge, which is supplanted by a three-span, concrete-arch bridge on the top of the diversion dam. The new highway required to replace portions of the existing

road which was flooded was completed in the Fall of 1923. The diversion dam is of the concrete overflow type, having a spillway portion 270 ft. long capable of passing floods of 70,000 sec. ft. capacity, without overtopping the ends of the dam. This is greater than the estimated maximum flood which might occur. In order to prevent erosion of the stream bed when floods are passing over the crest, an extensive apron is constructed below the dam. Near the upstream end of the apron there is placed a group of baffle piers designed to absorb the greater portion of the energy of the swiftly moving waters. Three sluice gates, each 7 ft. square, are placed near the bottom of the dam to unwater the reservoir, should this ever become necessary.

Water is diverted through a tunnel 19 ft. in diameter, 21,230 ft. long and reinforced-concrete lined throughout. The intake is located on the right bank 300 ft. upstream from the dam. The intake structure contains two large cast iron headgates 8 ft. wide by 18 ft. high, with an extensive screen or grizzly placed just upstream from the gates to prevent floating debris from entering the tunnel.

The first section of the tunnel emerges to the surface at Rock Creek Crossing, 8700 ft. below the intake. This short section, 230 ft. in length, is constructed as a 19-ft. diameter reinforced concrete pipe supported on a reinforced concrete trestle, so that the inside of the tunnel and pipe will form a continuous conduit of uniform cross-section. In order that no power be allowed to go to waste, provisions are made to direct the waters of Rock Creek into the tunnel, by constructing a small diversion dam across the creek, from which a pipe will carry the water to the tunnel.

From Rock Creek the tunnel continues 12,300 ft. to the lower portal on the hill above the power house site. An adit was provided to facilitate tunnel driving at a point 4640 ft. below Rock Creek.

At the lower portal the tunnel branches by means of a manifold into three large steel pipe lines, each having a diameter of 10 ft. and 9 in. Butterfly valves of the same diameter are provided just below the manifold, to permit taking any one pipe out of service for repair or painting, without shutting down the entire plant. Above these butterfly valves all construction is of such a nature that it should never be necessary to take the tunnel out of service.

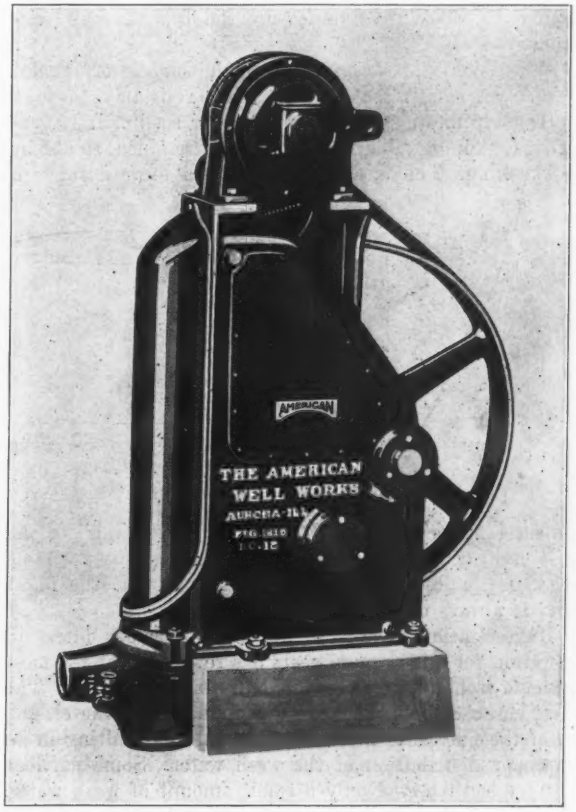
Three penstock lines continue down the 42 deg. slope of the hill approximately 330 ft. to the flat on which the power-house is located. At the beginning of this flat the pipes enter tunnels each 240 ft. long and continue to their juncture with the turbines in the main power-house building. Here again butterfly valves 9 ft. in diameter are provided for emergency use.

About 200 ft. upstream and 100 ft. to the south of the tunnel portal, a surge chamber 80 ft. in diameter and 90 ft. in height is provided to take care of the fluctuations in load on the plant. In the event of a plant shut down, the water will flow over the spillway lip and spill down the hill through a riveted steel waste pipe to the river 315 ft. below.

The power house is a steel frame building with concrete floors, walls and roof. The generator building, which houses the turbines and generators, is 195 ft. long and 49 ft. wide and 112 ft. high on the down stream side. The low tension switching equipment is housed in a rear wing 35 ft. wide by 162 ft. long. The generating equipment consists of three 33,000-hp. vertical-shaft turbines furnished by the Pelton Water Wheel Co., direct connected to three 27,000-kv.a. generators furnished by the General Electric Co. The 220,000-v. transformers and high-tension switching equipment were furnished by the Westinghouse E. & M. Co. and as at Pit No. 1 are located outside on the flat just above the power-house. From these transformers the power is fed into two transmission lines which span the river and climb the south canyon wall to the plateau above, on which the lines continue 8 mi., where they join the existing lines which were constructed to transmit the power from Pit No. 1 to the Vaca-Dixon substation 202 mi. away.

Deep Well Power Head Is Totally Enclosed

TOTAL ENCLOSURE of the entire pumping unit is one of the essential features of a line of deep well power heads recently placed on the market. The entire main



MAIN BEARINGS AND GEARS RUN IN OIL INSIDE THE POWER-HEAD FRAME

frame totally surrounds all gears, the whole machine being designed for safety, great rigidity and compactness of the head. All the main bearings and gears run in a bath of oil, which tends to make the operation of the head noiseless. All gears and pinions are machine cut and the pinions and pinion shafts are cut from a solid piece of machinery steel. The crank itself is of solid one piece construction.

These heads are made for both 6 and 12-in. strokes for operation with single-stroke cylinders. They are furnished either for electric motor drive or with tight-and-loose pul-

leys for gasoline engine drive. They are adaptable for use with tanks, and may be furnished complete with tanks and automatic starting and stopping devices. Frost-proof attachments are furnished for outdoor installations.

Bulletin 180, describing these single-stroke, totally enclosed power heads has recently been published by the American Well Works, Aurora, Ill., which manufactures them. The bulletin includes enginering data as to capacity and speeds and lists dimensions and foundation plans.

Self-Freeing Strainer Heads

CLARIFICATION of water by filtration is accomplished by passing the water through a sand bed consisting of grains suitably graded and sized, preceded, if required, by coagulation and sometimes by sedimentation. Filtration is essentially a screening and frictional resistance process. Suspended matter which is too large to pass through the interstices between the sand grains is strained out and retained on the surface of the filter bed, and smaller particles are retained by the bed through frictional resistance.

When the solids accumulate on the surface of the bed to such an extent that the frictional resistance through the bed becomes excessive, say 5 lb. per sq. in., it is generally found desirable to remove the retained solids by backwashing. The wash water is passed upward through

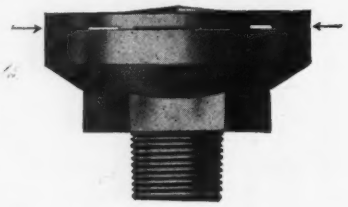


FIG. 1. DURING THE FILTERING PROCESS THE STRAINER HEAD IS SEATED

the filter bed at a rapid rate, causing a "boiling" of the sand and carrying off the suspended matter. At the same time, the sand is re-sorted or graded, so that the finest sand is always on top.

Investigation of a large number of various filters in operation for one or more years has revealed that the most common trouble of filters is difficulty in backwashing. The chief cause of this difficulty was found to be the closing up of the fine ports in the strainer valves, resulting in an improper distribution of the wash water. Some portions of filter bed received only a small amount of wash water, a consequently greater amount of wash water passing through the remainder of the bed where the strainer ports were not obstructed. To correct this common trouble a strainer valve with lifting head was designed by the Cochrane Corp., insuring the cleaning of the ports during backwashing. As illustrated, during the filtering process the strainer head or cover is seated, leaving only small ports for the water to enter and preventing the passage of sand. The size of the port openings is so determined that to pass the required amount of wash water through each valve, the head will be lifted against the downward pressure of the sand and gravel. This slight lifting of the strainer head releases any foreign particles in the ports and permits the wash water to sweep them away. This type of strainer can be backwashed with unfiltered water, as any silt or other finely suspended solids in the unfiltered water will readily pass through the strainer valves. A storage tank to provide a supply of filtered water for backwashing is therefore not needed.

Referring to the accompanying illustration, when the filter is in operation the water entering the filter inlet valve is uniformly distributed over the filter bed, passes downward through the latter and is collected by the strainer system, which discharges through the filter outlet valve.

When backwashing, the wash water enters through the wash water valve and is distributed by the strainer system under the entire filter bed, with an upward flow of approximately 12 to 15 gal. per sq. ft. per min., which causes the sand to be slightly agitated or "boiled," cleansing the sand grains and carrying to the sewer the suspended mat-

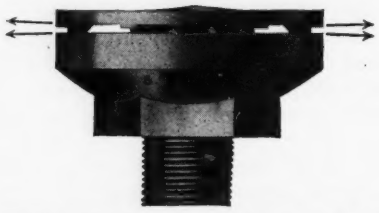


FIG. 2. LIFTING OF THE STRAINER HEAD RELEASES FOREIGN PARTICLES

ter which has been retained by the filter bed during the filtering period. A differential gage connected to the two sides of an orifice in the wash water supply pipe serves as a flow meter and enables the operator to control the rate of back washing accurately. As soon as the wash water effluent begins to clear, as seen by watching the wash water discharge into an open funnel, the bed has been sufficiently backwashed and should be put back into service.

Aurora Plant of W. U. G. & E. to Be Enlarged

CONTRACT HAS been awarded by the Western United Gas and Electric Co. to Stone & Webster, Inc., for the installation of a 20,000-kw. turbo-generator unit to be installed in the present power house at Aurora, Illinois. Two additional 1000-hp. Stirling boilers with chain grate stokers are included in the contract. The entire forced draft system will be remodeled and new equipment will be installed. The boiler room substructure will be reconstructed, providing for ash tunnels and a fan room. A skip hoist for ash handling will be erected adjacent to the railway tracks. Extensions to the coal handling equipment will also be made. Dredging operations will be carried out in the river to improve the circulating water supply.

Electrical extensions will provide for the new 20,000-kw. unit and some additional improvements will also be made. In addition to this, 20 miles of 33,000-v. transmission line will be erected on wooden poles between Elgin and Glen Ellyn, Illinois, with a low tension substation at Glen Ellyn.

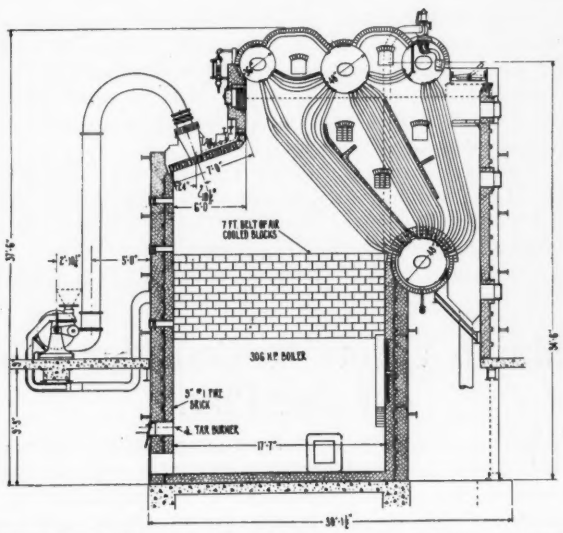
Stone & Webster, Inc., also has a contract with the Aurora, Elgin and Fox River Electric Company, a subsidiary of the Western United Gas and Electric Company, for an addition to their 33,000-v. substation at Elgin, Illinois.

Pulverized Coal Used by Gas Company

ONE INTERESTING installation recently made by the Heine Boiler Co. is that of a 306-hp. boiler, to be fired with either pulverized coal or tar, at the St. Joseph, Mo., plant of the St. Joseph Gas Co.

Side wall circulating air, the front tube tank of the boiler and the radiant type superheater are the only agencies that will keep the furnace temperature down. A special tube arrangement was developed for the front tube bank to absorb the maximum quantity of heat by radiation because the more radiant heat absorbing surface there is in a furnace the lower the total furnace temperature will be. There are only two rows of tubes entering the front drum and every other tube in the front row is moved forward.

This exposes the second row of tubes to the radiant heat reflected from the furnace side walls and the oblique rays from the flames. The surface exposed to radiant heat is thus doubled. The reduction in temperature due to this arrangement and also on account of the greater spacing between tubes will prevent slagging at the higher ratings.



SEVEN-FOOT BELT OF AIR-COOLED BLOCKS PLACED IN SIDE WALLS

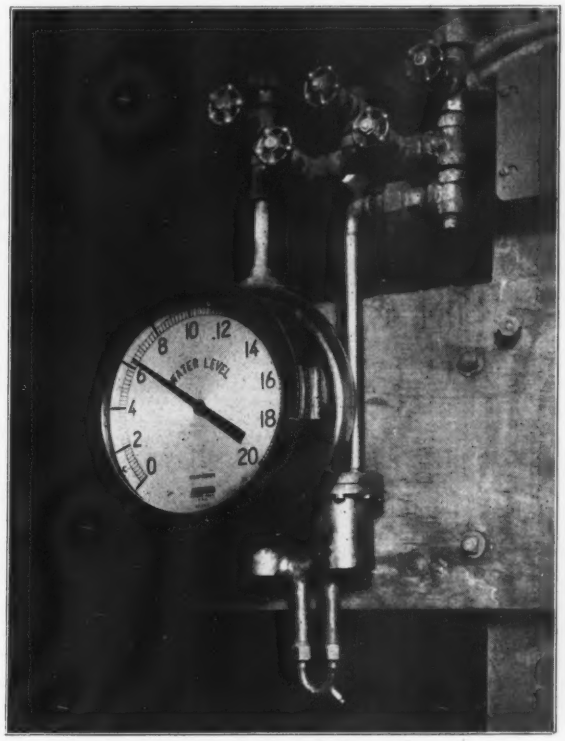
The preheated air from the furnace walls passes through the pulverizing unit to carry the pulverized fuel to the furnace. In many installations preheated air is used as secondary air only. In this arrangement the secondary air is not preheated.

This boiler is also equipped with Power Specialty Co. radiant-type superheaters located in the rear furnace wall below the air-cooled zone. The rear wall of the setting is carried only a few feet below the water drum, in fact, only far enough to provide for a hopper to catch fly ash and heavier soot particles. This construction uncovers the lower portion of the water drum and keeps the blowoff connections and lines entirely out of the boiler setting.

This boiler will also be fired with by-product tar at times. The burner location for this fuel is shown in the front wall near the bottom of the furnace. The boiler contains 3060 sq. ft. of heating surface and is built for 199 lb. working pressure.

Gage Shows Water Level in Boiler

ONE USE FOR A boiler water level gage, secondary in the case of a recorder but primary where an indicating model is used, is the duplication of the purpose of the glass gage on the boiler drum. Gage glasses soon become fouled on the walls, both inside and out and are hard to read, especially since they are often located up in a poorly lighted spot, high above the operating floor. The Foxboro Co.'s boiler level gage may be placed at eye level on the firing floor, thereby giving the operator a continuous, easily read indication of the water level in each boiler or battery.



THIS IS THE INDICATING TYPE GAGE

This instrument operates by the differences in head between maximum high water and any intermediate point. The fundamental principle is that of the mercury-float, differential mechanism, in which the difference of pressure on each leg of a mercury U-tube causes a deflection of the mercury, thus actuating the pen arm through the rise and fall of the float. This float is connected to the pen through a patented pressure-tight and non-corrosive bearing.

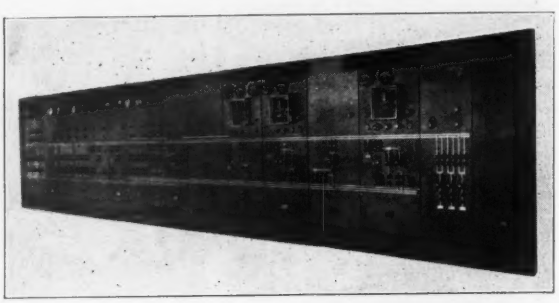
Work Started at Wallenpaupack Creek Development

DETAILS ARE being perfected and work is under way on the proposed hydroelectric generating plant to be constructed on Wallenpaupack Creek, near its junction with the Lackawaxen River, near Lackawaxen, Pa., estimated to cost close to $8,000,000, with power dam and transmission system. The project is one of the Pennsylvania Power & Light Corporation, Allentown, Pa., operated by the Electric Bond & Share Co., New York. The power dam

will be located near Wilsonville, about 1½ mi. above the mouth of the creek, while the generating station will be situated on the south bank of the Lackawaxen River, approximately 2¾ mi. below the mouth of Wallenpaupack Creek, giving a maximum water head of 373 ft. The dam will be of earth and concrete type, 60 ft. high and 1150 ft. long. A reservoir will be built with a surface area of 5760 acres and rated capacity of 70,500,000 gal. It will be of sufficient size to store about 50 per cent of the average annual run-off of the stream. The transmission system will connect the new hydroelectric power station with the steam-operated plants of the company at Hauto, Harwood and Wilkes-Barre, as well as other smaller similar stations in various neighboring localities. The new plant will have an initial capacity of 53,600 hp., divided into two main generating units.

Steel Switchboard Proves of Commercial Value

STRETCHER Level sheet steel is the material of which a new switchboard recently developed by the Westinghouse Electric & Mfg. Co. is made. This new type of



STEEL SWITCHBOARD INSTALLED ON STATEN ISLAND

switchboard, a view of which is shown in the accompanying illustration, is light, substantial and sturdy and may be used in power, railway, industrial and marine installations.

The influx of steel switchboards has been a gradual one since 1915 when it was found that the ordinary slate and marble boards would not stand up under severe operating conditions. They were brittle and easily broken and were subject to stain by oil, which marred the appearance of the board. In addition they were heavy and cumbersome.

For some time stretcher level steel switchboards have been used on small installations in a more or less experimental way and have proved successful, so that they are now being installed on larger projects. The outstanding features of this new type are its lightness, substantial nature, appearance and inexpensiveness. The erection and maintenance costs are lower than those of the slate and marble boards. The erection, in addition to being cheaper, is more simple, since the framework is an integral part of the panels.

The steel panels are given a baked enamel finish similar to that used in the auto industry. They thus present a most pleasing appearance and in addition are impervious to moisture and easily resist the corroding action of salt sea air.

From the power and railway standpoint the most important installations are those of the Staten Island project which is part of the complete electrification of the B. & O. system from Baltimore to New York and the installation in the automatic sub-stations of the Steubenville, East Liverpool and Beaver Valley Traction Co.

Technical Program for N. A. S. E. Convention

TENTATIVE technical papers program for the National Association of Stationary Engineers' convention, which is to be held in St. Paul, Minn., Aug. 31 to Sept. 4, has recently been announced.

Tuesday afternoon, Theodore Thou, chief engineer of the Ideal Electric & Mfg. Co., will talk on "The Evolution of the Synchronous Machine From the Earliest to the Present Time. Flywheel Type Synchronous Motors, a Review, a Prediction."

Tuesday evening will be devoted to the showing of motion pictures of the electrical industry with E. H. Sniffen, power sales department of the Westinghouse E. & M. Co. Pictures to be shown are: "A Trip Through the Westinghouse Works," "An Electrical Travelogue," and "White Coal."

Wednesday morning will be given over to Joseph F. Shadgen, combustion engineer with the Smoot Engineering Corp. His subject will be "Centralized Combustion Control by Mechanical Means and Methods of Handling Large Unit Boilers at Highest Ratings Obtainable at Highest Possible Efficiencies."

Thursday morning, "Power Factor, Low Power Factor, How Corrected, Applications of Motor-generator Sets and Voltage Control of Machines Through Them," by a speaker from the Electric Machinery & Mfg. Co.

Thursday afternoon, a welfare paper will be presented.

Maine Voters to Consider Tide Water Plant

UPON THE VOTE of the residents of the state of Maine in September rests the immediate development of huge power projects which may ultimately supply power not only to that state, but to a large section of the Atlantic seaboard. In September the vote is to be taken. Maine has had upon its statute books for generations a law preventing the export of power beyond the boundaries of the state. Purchasers of Maine power companies by outside interests have been frequent, but the greatest project of them all is the development of tide water power as proposed by Dexter P. Cooper, engineer in charge of the project, which has the financial backing of hundreds of wealthy Maine residents. Development of his project resulted in the appearance of the so-called Cooper Bill in the state legislature and it is upon this bill that Maine casts its ballots in September.

This bill would permit the export of power manufactured at the proposed tide water plant besides permitting the construction of the plant. The project is one of unusual engineering interest. In the Passamaquoddy Bay, partly closed in on the one hand by the easternmost arm of land in the United States and on the other side by New Brunswick and Nova Scotia, are two large bays within the territory of the United States, known as the Upper and Lower 'Quoddy bays. Both these bays are

swelled by the incoming tide, which rises many feet above low mean water level.

Across the narrow strip of land dividing the two bays, it is proposed to build a dam, also to construct a second dam across the outlet of the Lower 'Quoddy with large water gates. The upper dam would make a huge reservoir of the Upper bay which would be filled at each high tide. The lower dam would operate directly opposite to the Upper dam; that is, the gates would be closed against the rising tide and opened at low tide to permit the escape of water which had passed through the power plant on the Upper dam during the flow and ebb of the tide.

Careful study has shown that at no time would the water in the lower basin reach the height of that in the upper basin, no matter how great a quantity was used in generating current at the power plant, hence there would be a continuous flow of water into the turbine generators. The proposed dam construction would in no way interfere with the use of Passamaquoddy Bay by shipping interests.

According to estimates, the cost of the dams and erection of the power plant will involve an expenditure of approximately $100,000,000; between 500,000 and 700,000 horsepower will be generated; it will require about 4 yr. to complete the work and approximately 5000 men will be required to build the dams and powerhouse. Mr. Cooper stated that if favorable action was taken by Maine voters in September, his associates and himself were ready to start actual work in October.

Passamaquoddy Bay lies practically at the mouth of the Bay of Fundy, where the tides run from 12 to 70 ft. in height.

News Notes

Applications have been filed by about twenty leading American colleges and universities for their students of chemistry and chemical engineering to take the one week course of intensive training in practical technique of chemical engineering to be held in conjunction with the Tenth Exposition of Chemical Industries at the Grand Central Palace, New York, during the week of September 28 to October 3. More than 300 students are expected to enroll before the closing date. All students of recognized colleges, as well as practicing chemical engineers, who desire to brush up on fundamentals, are eligible to take the course which is without cost.

Announcement will be made at an early date of the program of lectures for the course for students which is now being made up. Some of the leading authorities on engineering methods, materials and equipment will be among the speakers. Lectures will be held during the morning hours at the Grand Central Palace prior to the official opening of the Exposition each day. Tours among the exhibits for practical demonstrations will also be conducted for the students. Professor W. T. Read of the Chemistry Department of Yale University, is in charge of the course.

McClellan & Junkersfeld, Inc., Engineers and Constructors, of New York, St. Louis and Washington, D. C., are now represented in Chicago by Stephen Gardner, as District Manager, with offices at 203 South Dearborn St., Chicago. Mr. Gardner will continue also as President of the Industrial Engineering and Sales Service, Inc., of Chicago.

Armstrong Manufacturing Co. has recently appointed the Pitts and Kitts Manufacturing and Supply Co., of 91 Seventh Ave., New York City, as Eastern representative. The office is in charge of J. Arenholz.

Announcement has just been made of the consolidation of the Dempsey Furnace Co., of Jersey City, N. J., and the W. N. Best Corp. in New York City. The combined furnace business of the two companies will be operated as the Dempsey Furnace Division of W. N. Best Corporation, under the personal direction of H. B. Dempsey. This consolidation will increase the facilities for manufacture and will permit a more complete line of industrial furnaces.

Preliminary plans are under way by the Ohio Public Service Co., Cleveland, for the construction of a steam-operated electric generating plant on the Ohio River at Dilles, about 5 mi. south of Bellaire. The initial plant will be equipped for a capacity of 100,000 hp., later to be increased with the installation of additional units to a maximum of 500,000 hp. No date, as yet, has been decided upon to begin work. The complete project, with steel tower transmission line, is estimated to cost close to $7,500,000.

The Public Service Co. of Northern Illinois has recently placed an order with Allis-Chalmers Manufacturing Co. for a 50,000-kw. steam turbine unit to be installed in the Waukegan Station. This is the third unit for this station, all of Allis-Chalmers manufacture, the first, having a capacity of 25,000 kw., has been in operation for a number of years. The second unit, with a capacity of 35,000 kw., was placed in operation last winter. The new unit as well as the two units previously installed operate in connection with Allis-Chalmers condensers.

Hibbing, Minn., Municipal Water & Light Dept. has now under way the 1925 plant extension program. This will double the size of the present building housing the boilers, a brick and steel structure, where one new Kidwell 800-hp. water-tube boiler will be installed, together with Taylor stokers, which will also be applied to the boilers now in use. New boiler room accessories, feed water equipment of larger capacity than that now in use will also be installed, together with Foster superheaters. A new and larger re-inforced concrete stack will also be built.

At its River Furnace plant, Cleveland, the McKinney Steel Co. will install a 9000-hp. synchronous motor which will have the highest continuous horsepower rating of any industrial motor in the world. This motor will be direct connected to a Morgan continuous billet mill which will probably be in operation early in 1926. The mill will have ten stands of rolls, six of which will be 21-in. and the remainder 18-in. The motor will be made by the General Electric Co. and will be rated 9000 hp., 107 r.p.m., 6600 v., 3 phase, 25 cycles to operate at unity power factor. The motor will have a shaft extension on both ends and will be coupled to a long lay shaft running the length of the mill with bevel gearing to each stand of rolls. This will be the first large steel rolling mill to be driven by a synchronous motor. Practically the only other instance of an application of this kind is in the case of some tube rolling and piercing mills in this country which are driven by synchronous motors of approximately 1000 hp. The usual practice has been to drive such a mill by an induction motor.

WISCONSIN PUBLIC SERVICE CORP. is enlarging the steam generating station at Oshkosh, Wis., by adding one Allis-Chalmers 5000-kw. turbo generator with a surface condenser and all auxiliary equipment of Allis-Chalmers manufacture.

BUHL, MINN., Water and Light Dept. is now installing two Springfield boilers of 350 hp., equipped with Frederick stokers, which are also being installed under the boilers now in use, a Casey-Hedges and an Erie City. Coal and ash handling equipment will also be installed, which will necessitate additions to the present building.

CONSTRUCTION WORK on a new local steam plant and steam-heating system, in course of building for a number of months past, is being pushed by the Rochester Gas & Electric Co., Rochester, N. Y., which proposes to have the work completed ready for service late in October. The system will be used for the business section of the city and will represent an investment of more than $1,500,000.

ANNUAL MACHINE Tool Exhibition will be held Sept. 8 to 11 at the Sheffield Scientific School of Yale University, New Haven, Conn. Technical sessions will be arranged by the Machine Shop Practice Division of the A. S. M. E. and entertainment of visitors, which will be looked after by a committee from the University and the business men of New Haven, will include visits to important industrial plants, sight-seeing trips, dinner meetings, golf and other pastimes. Two additional floors of Mason Laboratory have been allocated to the exhibit because of the demand for space. Hotel reservations at the Taft or the Garde should be made well in advance.

Books and Catalogs

HEAT ENGINES, by H. R. Allen and J. A. Bursley. Third edition, 1925, revised; 422+XV pages, 233 illustrations; cloth, 6½ by 9 in.; New York; price $4.00.

In its first two editions, this book was intended as a text for use in elementary college courses in mechanical engineering and the same purpose has been kept in mind in this edition. Use of the calculus has been entirely avoided except in the chapter on thermodynamics.

In the first three chapters, the elementary theories of heat, thermodynamics and properties of steam are discussed, several new paragraphs on entropy having been inserted. Then follow chapters on fuels, boilers and auxiliaries, engines and turbines, and their auxiliaries, and internal combustion engines. The last chapter on economy of heat engines, although too brief, is sufficient to call to the attention of the student the fact that considerations other than those of thermal efficiency govern the selection and operation of the equipment discussed. Convenient steam tables are included for reference. Photographs and drawings of the latest types of equipment, together with descriptive text, have been added to bring the book up to date.

Heat Engines should prove useful to the operating engineer, as it will give him a knowledge of the elementary thermodynamic principles that govern the operation of the equipment he must deal with every day, without demanding of him an extensive knowledge of higher mathematics.

AMERICA'S GREATEST DAM, by Wm. Benjamin West; second edition, 1925, revised; cloth, 11 by 8 in., 64 pages, 54 illustrations; New York; price $2.00 net, postpaid.

Much of the confusion existing in the public mind, in regard to the Muscle Shoals development, created by conflicting newspaper and magazine articles, will be dispelled by the facts given by Mr. West in the second edition of his book. In the first half, he discusses the whole project in its economic aspects, showing why the Wilson Dam and the two nitrate plants were constructed at this point, and how the provisions of the National Defense Act, and of the contract between the Government and the American Cyanamid Co. have introduced many legal complications into the situation.

In the second half of the book, the two nitrate plants, their chemical processes and steam power plants, the hydro-electric plant and the dam structure are discussed in detail, together with some of the physical characteristics of the Tennessee River. Many splendid illustrations show various phases of this great development.

As the construction of this plant has been a great and costly undertaking, its proper economic utilization in time of peace, as well as its value as a producer of explosives in time of war, should be a matter of the greatest concern to every American citizen. The author has performed a valuable service, not only to the engineering profession, but also to the whole country, by presenting this information so clearly and forcefully.

DIESEL & OIL ENGINEERING HANDBOOK, by Julius Rosbloom. Third edition, 1925; Keratol, 5 by 7 in.; 786 pages, illustrated; Los Angeles, Calif.; price $5.00.

To cover the whole field of Diesel and oil engineering practice in one volume is an ambitious attempt, but Mr. Rosbloom's book comes closer to doing it than any other we have seen. It deals more with construction and operation features of the oil engine than with design, and it should prove a convenient reference work for both the stationary operator and the marine engineer.

Practically every type and make of pure Diesel engine is discussed in detail in the first 300 pages. Chapters are included on Diesel electric drives, pumps, semi-Diesel engines and the latest applications of the oil engine to the locomotive, the automobile and to industrial work. Since the oil engine is so widely used in marine practice, considerable information on marine engines is given, with rules for licensing of marine engineers, maneuvering signals and the like.

Question and answer sections should prove useful to the operator, together with the discussions of formulas, the indicator, piping and auxiliaries. The book also contains an unusually complete assortment of data tables and conversion tables. A chapter on machinery used in the petroleum industry rounds out the subject.

Several hundred photographs, sketches and blueprints add much to the interest of the text. It is revised four times a year and is thus kept strictly in accord with the latest practice.

TRAPOLOGY is the title of a catalog just issued by the Boylston Steam Specialty Co., of Chicago, describing and illustrating the various types of Boylston traps and giving valuable information on the selection and use of traps for different services.

A. C. E. CORLISS VALVE steam traps are the subject of Catalog "A," recently issued by W. B. Connor, Inc., New York City. The catalog shows in detail the design, construction and method of operation of these traps which are of the float type.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

In the Fullness of the Year

Fields yellowed with ripening grains are shorn with great machines and dotted with stacks.

Another abundant harvest is being gathered and stored, ready for the myriad processes of preparation and distribution.

Billions of wealth in raw materials are added in this way to the resources of the nation to find their way to factories, offices, stores and the many other institutions which directly supply the people.

Out of that abundance comes, in turn, increased demand for transportation, for manufacture, for transaction of business, and, finally, for better living.

To supply this demand, billions more of wealth in coal, minerals and other raw materials are drawn from the earth, to pass through countless other processes.

For rooted in all these processes of industry is every mighty building or modest cottage, every bank, railway, publication, school, college or other institution of civilized man.

Out of the yearly increasing abundance of the fruit of the earth and the wealth from beneath the earth, men are forging a greater and more abundant civilization.

Almost daily we can see advance in standards of living while in not far distant past such advance was so slow that it was scarcely perceptible from generation to generation.

Those who are thinking in terms of the past see the world rushing to a dismal end. To them old methods of agriculture, power generation and manufacture; old ways of living, old buildings, machinery and plants are good enough and the increasing speed of changes and replacement seems wanton waste.

Sheer overabundance of wealth of raw resources, coupled with the aspirations of a mighty and capable people are sweeping onward.

Nor is there now in sight nor likely to become visible any stop or let-up. For today there are thousands of pioneers, as there were in former generations, reaching out into the infinite vistas of natural law and bringing new knowledge to bear on daily problems and then applying it to human service.

While the good old earth brings forth its fullness and from its depths contributes the resources laid down in past ages, a truly vaster wealth is being contributed by man himself through new discoveries in and better manipulation of these earth-given resources.

Compare the opening of the West, that golden age of new soil spread to the horizon, with the increased yields per acre that improved machinery and farming methods have contributed in the last 20 years alone.

Compare the opening of oil fields, another so-called golden age when a few fortunes were founded but when the vast majority of oil men went broke, with the billions of wealth contributed by better refining and marketing methods and the vast new equipment for getting more out of a gallon of crude oil than was dreamed of by those pioneers.

What discoveries of coal beds in the history of the world can compare with the improved utilization of coal that in a decade has made one pound of coal yield the power that five pounds gave before?

Throughout the countless ramifications of industry and in its multitudinous processes, like improvements are being made, one such improvement ofttimes saving resources of time, materials, labor or thought worth millions of dollars annually.

Each such discovery and application pours forever afterward its ceaseless contribution into the common wealth for the use of humanity until further improvement in turn contributes a greater volume of wealth.

Men who are doing things in a practical way—hard-headed men, thrifty men, men who are leaders in every industry, every branch of business—know that they can scarcely discover, improve, build and expand fast enough to keep up with the three-fold forces that are today driving onward.

Natural resources our fathers had. Today they are being produced as never before. Utilization of them, man's dominion over Nature, is progressing by leaps and bounds. Desire for a more abundant life and better living, a primeval urge, suddenly has speeded up.

Through all the nation's life, from raw materials to finished products, and as essential to production and utilization as coal, corn or other resources themselves, power, the energy without which civilization itself would cease to be, weaves, guides, hoists and draws from place to place.

Unlimited are its possibilities of improvement; uncounted the opportunities for its better generation; unceasing the demand upon it for the improvement of all other processes of industry.

Power plant men who recognize the opportunities before them for personal advancement and service to mankind, find in these pages the means at hand for successful accomplishment.

For hundreds of new plants and thousands of old plants improvements are to be found in the machinery, equipment and supplies advertised in these pages.

Applying them, getting them to work for you, is the measure of the man who reads and the time is short to prepare for the work of power plants in the fullness of the year.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR CHAMBERS
Hercules Float Wks., Springfield, Mass.
AIR COMPRESSORS
Allen & Billmyre, Inc., New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Murray Iron Works Co., Burlington, Iowa.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.
AIR FILTERS.
Allen & Billmyre, Inc., New York.
Spray Engineering Co., Boston.
AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.
ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
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ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Lavino & Co., E. J., Philadelphia.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
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ASH AND COAL BINS.
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ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyor Corp., Chicago.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.
ASH TANKS.
Conveyors Corp. of America, Chicago.
United Conveyor Corp., Chicago.
BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.
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Strong, Carlisle & Hammond Co., Cleveland, Ohio.
BEARINGS.
National Tube Co., Pittsburgh.
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Stearns Conveyor Co., The, Cleveland, Ohio.
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Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.
BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.
BELT LACING.
Bristol Co., The, Waterbury.
Flexible Steel Lacing Co., Chicago.
BELTING.
New York Belting & P'k'g Co., New York.
Pioneer Rubber Mills, San Francisco.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.
BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.
BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.
BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Hyde Park, Mass.
BLOWERS, PORTABLE.
Allen & Billmyre, Inc., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
BLOWERS, STEAM.
Schutte & Koerting Co., Phila.
BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Sherwood Mfg. Co., Buffalo, N.Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.
BLOWERS, TURBINE.
Allen & Billmyre, Inc., New York.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.
BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N.Y.
Quigley Furnace Specialties Co., Inc., New York.
BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chemical Co., Inc., New York.
BOILER COMPOUND FEEDERS.
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BOILER SETTING CEMENT.
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Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J., Philadelphia
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 148

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
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BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
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BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw,
BOOKS AND SCHOOLS.
Sweet's Catalogue Service, Inc., New York, N. Y.
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BRICKS, FURNACE LINING.
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BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.
BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
BUCKET ELEVATORS.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.
CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, O.
CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.
CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry. Inc., Troy, N. Y.
CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.
CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
King Refractories Co., Inc., Buffalo.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J., Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Quigley Furnace Specialties Co., Inc., New York.
CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.
CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.
CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.
CHIMNEYS.
American Chimney Corp., New York.
CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The Hartford, Conn.
Sherwood Mfg. Co, Buffalo,
CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.
COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.